The Influence of Arousal on Moral Decision-making for Individuals with and without Mild Head Injury

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Abstract

Recent research has shown that University students with a history of self-reported mild head injury (MHI) are more willing to endorse moral transgressions associated with personal, relative to impersonal, dilemmas (Chiappetta & Good, 2008). However, the terms 'personal' and 'impersonal' in these dilemmas have functionally confounded the 'intentionality' of the transgression with the 'personal impact' or 'outcome' of the transgression. In this study we used a modified version of these moral dilemmas to investigate decision-making and sympathetic nervous system responsivity. Forty-eight University students (24 with MHI, 24 with no-MHI) read 24 scenarios depicting moral dilemmas varying as a function of 'intentionality' of the act (deliberate or unintentional) and its 'outcome' (pbysical barm, no physical harm, non-moral) and were required to rate their willingness to engage in the act. Physiological indices of arousal (e.g., heart rate - HR) were recorded throughout. Additionally, participants completed several neurocognitive tests. Results indicated significantly lowered HR activity at baseline, prior to, and during (but not after) making a decision for each type of dilemma for participants with MHI compared to their non-injured cohort. Further, they were more likely than their cohort to authorize personal injuries that were deliberately induced. MHI history was also associated with better performance on tasks of cognitive flexibility and attention; while students' complaints of postconcussive symptoms and their social problem solving abilities did not differ as a function of MHI history. The results provide subtle support for the hypothesis that both emotional and cognitive information guide moral decision making in ambiguous and emotionally distressing situations. Persons with even a MHI have diminished physiological arousal that may reflect disruption to the neural pathways of the VMPFC/OFC similar to those with more severe injuries.

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Dedication

This research is dedicated to the following people, who inspired and maintain a shared vision that studying the effects of brain injury is a worthy cause. To God – who taught me that all things are possible through Him. Thank you for your provision, love, and support. To my sisters – who started on this journey with me, supported, encouraged and believed in me although miles apart. Thank you so much. To my friends – thank for you for help.

Table of Contents

List of Tables

List of Figures

List of Appendices

The Influence of Arousal on Moral Decision making for Individuals with or Without Mild Head Injury

Consider the following moral dilemma by Greene, Sommerville, Nystrom, Darley and (2001):

> Enemy soldiers have taken over your village. They have orders to kill all remaining civilians. You and some of your townspeople have sought refuge in the cellar of a large house. Outside you hear voices of soldiers who have come to search the house for valuables. Your baby begins to cry loudly. You cover his mouth to block the sound in order to prevent his crying from summoning the attention of the soldiers, who will kill you and your child and the others hiding in the cellar. To save yourself and the others you must smother your child to death. (p.22)

Is it morally acceptable to smother a child in order to save yourself and others? In response to this question, most persons readily condemn the violation and in instances when they approved similar violations, their reaction time was assessed as slow (Greene et al., 2001).

What accounted for these judgment patterns? Some researchers (e.g., Bechara, Damasio & Damasio, 2000; Greene et al., 2001; Haidt, 2001) suggested that in situations of uncertainty, a person's decisions and cognitions are guided by emotional reactions. If this is true, then what happens to a person who experiences reduced emotional feedback arising from diffuse brain injury? Would he or she be more inclined to decide to intentionally smother the baby in the above scenario? Specifically, would university students diagnosed with mild head injury (MHI) who are, reportedly, physiologically underaroused (e.g., Baker & Good, 2010; Chiappetta & Good, 2010; St. Cyr & Good, 2008; van Noordt & Good, 2010), exhibit differences in their decisions regarding moral violations that have been manipulated to reflect different levels of intentionality (deliberate versus accidental). If there are confirmed differences, what is the implication for these persons' behavior in the society? This study was designed to address these questions and specifically, explored the relationship between MHI and moral decision making and the impact of arousal on this relationship.

A moral decision can be defined as a choice made by an agency that is based on a set of agreed on moral principles (Ciaramelli, Muccioli, Lodavas, & di Pellegrino, 2007). Many psychologists and philosophers, such as Hume, Kant, (as cited in Barth, 2006) and Piaget (1965), view it as the result of two processes: rational reasoning and intuitive emotions (e.g., Barth, 2006; Haidt, 2001; Kohlberg, 1981). Kant (1785, as cited in Barth, 2006) posited that moral decisions were the consequence of thoughtful and conscious reasoning. In line with this approach, early views of moral psychology, such as Kohlberg's theory of moral development (Kohlberg, 1981), emphasized the importance of the maturation of thinking style (i.e., the progression from an "ego-centric viewpoint" to a more "universal-law based" way of thinking) and moral principles in driving moral decision.

Hume, on the other hand, (1758, as cited in Barth, 2006), contended that moral decisions developed from immediate aversive feelings based on observed or imagined violations to victims. In support of this view, more recent theories such as Haidt's (2001) 'Social Intuitionist Model' emphasized that emotional reactions are elicited immediately when faced with a moral dilemma, which is then followed by slower, post-hoc reasoning for those judgments. In this regard, two studies have demonstrated that when individuals are confronted with dilemmas depicting some disgusting actions (e.g., incest or pushing a fat person to his death), they immediately decide that these actions are unacceptable but are unable to articulate any justifications for their stance. Haidt referred to this as moral 'dumb founding' (Haidt, 2001;

Hauser, Cushman, Young, Jin & Mikhail, 2007). Similarly, Haidt and Hersh (2001) found that intuitive reactions rather than perceptions about harm were better predictors of judgments of moral issues using examples such as homosexuality, masturbation and incest.

The above findings suggest that emotional processes can influence moral decisions and as will be examined shortly, evidence from neuroimaging and clinical studies with individuals suffering from brain injury endorsed the significance of emotional brain areas such as the orbital frontal cortex (OFC) and the ventro-medial prefrontal cortex (VMPFC) in guiding certain aspects of moral decision making (e.g., Anderson, Bechara, Damasio, Tranel & Damasio, 1999; Ciaramelli et al., 2007; Cushman, Young & Hauser, 2006; Eslinger & Damasio, 1985; Greene & Haidt, 2002; Greene et al., 2001; Koenigs et al., 2007).

Head Injuries: Classification and epidemiology

Traumatic brain injury (TBI) involves injuries to the brain due to sudden inertial forces to the head (Gaetz, 2004) and varies along a continuum of severity level and type due to the size of the force and location of brain lesions. At one end, a severe blow to the head that penetrates the skull can lead to death and coma, due to skull fractures, hemorrhage, edema, intracranial pressure, immense and irreparable tissue damage (Leetsma, 1988). This kind of injury is referred to as open-head injury (Kolb & Whishaw, 2003). At the other end of the continuum, there are moderate to milder brain injuries resulting from lesser forces, which may or may not involve skull fractures. Within the milder range of injuries are complicated mild traumatic brain injuries (MTBI), which are characterized by a Glasgow Coma Scale (GCS) of 13-15 and by intracranial abnormalities (e.g., hematoma, contusions) that are visible on CT scans (Iverson, 2005). By contrast, uncomplicated MTBIs do not have any intracranial defects or skull fractures and are usually associated with better neurobehavioural outcomes compared to complicated

MTBIs (Iverson, 2006). Taken together, these injuries are referred to as closed head injuries (CHI) (Kolb & Whishaw, 2003). They are mainly confined to the anterior regions (e.g., frontal and temporal regions) of the brain (Hofman et al., 2001; Holbourn, 1943; Umile, Sandel, Alavi, Terry & Plotki, 2002), recently verified by diffuse tensor imaging (DTI) techniques (Hartikainen, 2010; Noigi & Mukherjee, 2010). The continuum of severity of traumatic brain injury is shown in Figure 1.

Very mild/transient Uncomplicated mild Complicated mild Moderate Severe Catastrophic
---------------------At least 90% of all injuries---------------------

Figure 1. Continuum of traumatic brain severity. Adapted from "Moderate and Severe Traumatic Brain Injury" by G.I. Iverson and R.T. Lange, 2011, in M.R. Schoenberg & J.G. Scott (Eds.), *The little black book of neuropsychology: A syndrome based approach.* New York: Springer.

It is estimated that 57 million persons worldwide have been hospitalized with one or more TBIs (Langlois, Rutland-Brown & Wald, 2006) and, in Canada alone, there were 16, 811 hospitalizations in the period of 2003-2004 (Canadian Institute for Health Information (CIHI), 2006). Approximately, 80-90% of these cases were mild (Cassidy et al., 2004), while moderate and severe TBI represented 10% of these cases respectively (Kraus & Chu, 2005). MTBI has been described as an epidemic in industrialized countries due to high incidence rates — 500/100, 000 (Bazarian, et al. 2005) and the rising health costs associated with its residual sequelae (Gue'rin, Kennepohl & McKerral, 2006) annually. However, the true scope of MHI may be underestimated owing to the various definitions of MHI used and the fact that only 75% of individuals with MHI seek medical assistance (Sosin, Sniezek & Thurman, 1996).

Additionally, at least 200,000 cases go unreported because they are seen in a doctor's office or in clinics (Finkelstein, Corso & Miller, 2006).

TBI affects the entire lifespan but certain age-groups have been identified to be more vulnerable to these injuries. Individuals under the age of 19 years comprise the majority of victims of TBI and in children there are two peak periods of occurrence: infancy and mid-to-late adolescence (CIHI, 2006). In this vein, McKinlay et al. (2008) found that approximately 30% of the sample in their study had sustained a MHI before age 25. Good and colleagues (e.g., Dzyundzyak, & Good, 2010; St. Cyr & Good, 2007, van Noordt & Good, 2010) found that 30-56% of high functioning university students reported a history of MHI. Children and adults, aged 0 to four and 75 years and older, respectively, also have a high incidence rate of TBI (Langlois et al., 2006).

TBI also occurs more frequently in certain groups. For instance, men are twice likely as women to obtain a TBI (Langlois et al., 2006) and military personnel serving presently in Afghanistan and Iraq are at risk for sustaining a TBI/MHI (Elder, Mitsis, Alhers & Cristian, 2010). In addition, approximately 87% of individuals who are incarcerated have reported a history of head injury (Slaughter, Fann, & Ehde, 2003).

The most common causes of TBIs are motor vehicle accidents, falls, assault, sports and recreational activities (Langlois et al., 2006). However, cases resulting in hospitalization reveal specific demographic trends. For example, adults (20-39 years) are more vulnerable to sustaining a TBI from motor vehicle accidents (51%) followed by assaults (20%) while youth and children, and adults over 60, are more likely to incur a TBI due to falls (40%, 76%, respectively), followed by motor vehicle accidents (39%, 17%, respectively). Sports and recreational activities account for 28% of youth injuries (CIHI, 2006).

Bio-mechanism of Head Injury

The mechanisms of CHI involve a sudden acceleration/deceleration of the head with significant rotational movement and stretching of brain tissue in the skull (e.g., Levin, Benton, & Grossman, 1982; Ommaya & Gennarelli, 1974). This kind of impact typically culminates in "coup-contrecoup" injuries as initial trauma propels the brain against one side of the skull ("coup"), and then causes it to rebound and collide with the opposite side of the skull ("contrecoup") (Ommaya & Gennarelli, 1974). These movements of the brain render the orbital and the anterior temporal cortices especially vulnerable to contusions, minor hematomas and edema, due to the forceful contact with the jagged internal geometry of the skull in these areas (Hofman et al., 2001; Varney & Menefee, 1993; Mayer & Schwartz, 1993; Umile et al., 2002). Furthermore, diffuse axonal injuries (DAI), a consistent feature of all TBI's, often occur due to the brain's exposure to rotational and acceleration/deceleration forces (Povlishock & Coburn, 1989). These injuries are distributed throughout the gray/white matter interface extending from cortex to the brain stem areas, the splenium of the corpus callosum and along the long fibres of the internal capsule (Gentry, Godersky & Thompson, 1988; Orrison et al., 1994) and can lead to impairments in axoplasmic transport and the accumulation of organelles (Povlishock & Christman, 1995). Notably, the extent of axonal injuries is proportional to the severity of the impact such that increased amounts of force produce more axonal damage (Kushner, 1998). Ultimately, these findings of macroscopic damages suggest that there may be a neurogenic basis for the emotional and behavioural sequelae associated with even minor forms of brain injury.

Pathophysiology of neurological disruption.

The pathophysiology that facilitates TBI-related neuronal dysfunction can be grouped into two categories: primary and secondary injuries. As noted before, primary injuries occur from initial impact and can lead to intracranial hemorrhage, contusion, shearing damages to brain tissue, and disruption to auto-regulation of cerebral blood flow. Conversely, secondary injuries arise from complex pathophysiologic processes such as hypotension and hypoxia (Kochanek, Clark & Jenkins, 2007). Giza and Hovda (2001) used animal models to investigate the secondary pathophysiology underlying MTBI and found a complex neurometabolic cascade which leads to diffuse cerebral swelling, neuronal, axonal and vascular damages.

Giza and Hovda (2001, 2004) demonstrated that immediately after a concussion, there is an efflux of potassium ions (Na+), which triggers an indiscriminant release of glutamate, an excitatory neurotransmitter, which binds to N-methyl-D-aspartate receptor (NMDA). This leads to further cellular depolarization that is accompanied by the continuous efflux of potassium and influx of calcium. This ionic imbalance activates the sodium-potassium pump (Na+ -K+) in an attempt to restore balance, which requires increasing amounts of adenosine triphosphate (ATP), thereby creating a rise in glucose metabolism. The resulting "hypermetabolism", coupled with reduced cerebral blood flow (an effect of the brain injury), produces a cellular energy 'crisis' as there is a discrepancy between glucose demand and supply. During this stage, postconcussive susceptibility is increased and the brain is incapable of dealing with a second injury.

Immediately after this wave of activity, the brain enters a period of 'depressed' metabolism. During this period, continuing elevated levels of calcium may compromise the role of the mitochondria in glucose metabolism and thus exacerbate the energy crisis. Additionally, persistent increases in calcium may lead to cell death and impair neural transmission. Collectively, these series of events contribute to neuronal dysfunction, axonal and vascular injuries that render the brain susceptible to postconcussive impairments.

These results are consistent with findings of subtle impairments in memory that have been associated with temporal lobe abnormalities in MHI patients (Umile et al., 2002). Moreover, they provide support for the model that proposes a deliberate relationship between damage to the brain and MHI-related cognitive and behavioral residual deficits.

Lessons from individuals with severe TBI

Neurological studies of individuals suffering from severe focal TBIs to the ventral-medial and orbital regions of the frontal lobe provide invaluable data for the affective neural basis of moral decision making. One of the classic cases providing evidence for the impaired moral behaviours associated with brain injury dates back to 1848 when Phineas Gage, a 25 year old railroad worker, suffered from accidental damage to the anterior regions of the orbital frontal lobe cortex (OFC).This resulted in profound personality changes as he became irresponsible, impulsive, childish, and displayed a lack of concern for social conventions and the needs of others, hallmark signs of 'Acquired Sociopathy'(Blair and Cipolloti, 2000; Damasio, 1994).

Contemporary individuals with "Gage-like" injuries also demonstrate the same neurobiological profile with slightly different moral outcomes based on one's age at injury (Anderson et al., 1999; Blair & Cipolotti, 2000; Eslinger & Damasio, 1985). The case of E.V.R, a happily married man who had tremendous success as an accountant, is one example. At the age of 35, he was diagnosed with a brain tumor. While the operation to remove the tumor was successful, E.V.R sustained bilateral injury to his OFC. Within months of this operation, deficits were observed in his interpersonal relationships and decisions. E.V.R's tardiness and irresponsibility led to several job losses and two failed marriages. He also invested his money with a scam artist and as a result had to declare bankruptcy. However, his performance on 'standardized' measures of moral reasoning and intelligence was unimpaired.

Similarly, Anderson et al.'s (1999) case study of two individuals demonstrated that prefrontal cortex (PFC) injuries extending to the fronto-polar regions acquired before 16 months of life produced impaired social behaviour such as lifelong lying, stealing, promiscuity, insensitivity to their own children, poorly regulated aggression, an inability to assess the social and emotional consequences of their decisions. They also displayed abnormal generation of skin-conductance responses (a measure of autonomic arousal) which indicated further emotional deficits. Further, while they exhibited relatively average intellectual skills, they were severely impaired on moral reasoning and judgment tasks and were generally lacking in moral knowledge illustrating the characteristics of 'Developmental Sociopathy'.

Several other studies (e.g., Ciaramelli et al., 2007; Koenigs et al., 2007) have demonstrated that adults with severe VMPFC lesions endorsed moral violations with utilitarian outcomes more frequently than non-injured controls. Koenigs et al. (2007), for example, examined how six individuals with VMPFC injuries made moral judgments using Greene et al.'s (2001) moral personal/impersonal test. In general, these individuals exhibited normal intellectual capacity and baseline moods but were impaired in the social emotions of embarrassment, guilt and empathy. Intriguingly, they gave more favorable ratings to high-conflict personal dilemmas that maximize aggregate well-being but are emotionally aversive (e.g., smothering a baby to save a group of people) relative to low-conflict personal (e.g., abandoning one's baby in order to avoid the burden of caring for it) and impersonal scenarios (e.g., keeping money found in a lost wallet). By contrast, those with no injury or other brain injuries were less likely to endorse these dilemmas. Further, non-injured participants took a longer time to endorse high-conflict scenarios when compared to low-conflict dilemmas.

Koenigs and colleagues (2007) interpreted these findings as support for the intuitive model of moral decision-making. The researchers argued that when non-injured persons are confronted with personal moral dilemmas, negative emotional responses are elicited and as consequence, they reject these violations. Conversely, individuals with VMPFC injuries are deficient in the social emotions necessary for moral decisions and, as a result, engage in utilitarian decision-making.

Consistent with these findings, Ciaramelli and colleagues (2007) found that non-injured participants were slower in their approval of 'personal' scenarios compared to less emotionally arousing 'impersonal 'dilemmas. On the other hand, individuals with VMPFC injuries were more likely to approve of, and respond more quickly to, the actions in the personal scenarios while their responses to the non-moral and impersonal dilemmas were similar to non-injured controls. Thus, in summary, these data suggest that emotions, which are mediated by VMPFC/OFC regions of the brain, are critical influences in the generation of moral decisions.

Somatic markers and decision-making

In order to explain the neurobiological deficits observed in individuals with frontal lobe injuries, Damasio and colleagues (Damasio, 1996; Damasio, Grabowski, Frank, Galaurda, & Damasio, 1994) proposed that 'somatic markers' and their evaluations influence decision-making and social functioning. According to this model, the OFC is a repository of neural representations of appropriate behaviours for certain situations which have been learnt from past experience. The emotional valence of these representations is linked with a somatic marker which is an autonomic nervous system response that codes the value of potential behavioural outcomes. In situations of uncertainty, emotions in the form of "somatic markers" (i.e., a person's 'gut feelings') guide decision-making by signaling the 'inappropriateness" of a contemplated action, leading to its rejection and the selection of more appropriate ones.

Empirical evidence has provided support for the effect of somatic markers on appropriate social responsiveness and advantageous decision-making. Two studies that investigated the autonomic responses to physical stimuli (e.g., noise) and psychological stimuli (scenes of social disaster, mutilation and nudity) found diminished skin conductance responses (SCRs) in persons with acquired VMPFC injuries relative to non-injured controls (Tranel & Damasio, 1994; Koenigs et al., 2007).

The use of the Iowa Gambling Task (a decision making paradigm that pits uncertainty, rewards and consequences together) also provides evidence for the influence of 'somatic markers' on decision-making. This task involves the presentation of four decks of cards in which two decks yield high rewards but result in higher punishments while the other two offer low rewards and an overall net profit if chosen consistently. Individuals with VMPFC injuries failed to develop a preference for the low-paying decks and did not show SCRs prior to choosing from the high-paying decks when compared to their non-injured controls (Bechara et al., 2000). Thus, it appears that OFC/VMPFC injuries disrupt autonomic input or activity such that there is limited capacity to produce anticipatory emotional responses to make advantageous decisions.

In subsequent studies, Tranel, Bechara and Denburg (2002) found a similar pattern of risk-taking behaviours among frontal lobe patients. In particular, patients with right lateral OFC damage had the worst performance on the IGT. Results from Fellows and Farah's study (2005) contradicted this functional specificity and indicated that dorsolateral prefrontal damage was associated with poorer performance on the IGT task irrespective of the hemisphere that was involved.

The inconsistencies in the foregoing IGT results are indicative of the inherent problems experienced when trying to relate a specific region of the frontal lobe to risk-taking behaviour. Nevertheless, these findings clearly demonstrate that changes in peripheral, and somatic, activity influence emotional behaviour and feedback from this peripheral arousal guides response selection and, ultimately, decision making.

Stimulus-reward learning and flexible behaviour

An alternative model for impaired decision making as a result of frontal lobe injuries emphasizes the role of reverse stimulus-response learning in modulating decision-making (Rolls Hornak, Wade, & McGrath, 1994). In general, a level of flexibility is required to make adaptive decisions when faced with contextual changes in one's environment. For instance, an insincere man may flatter a woman; however, after she recognizes his dishonourable intentions and predicts the negative outcome of being manipulated and hurt, she changes her behaviour by ending the relationship. By contrast, non-human primates and individuals suffering from OFC injuries are impaired at this flexibility as evidenced by their performance on stimulus-reward reversal tests. These tasks involve the presentation of two objects, one of which when chosen generates a reward. Later on, the contingencies are switched and the monkey or the individual must now learn to choose the correct object to obtain the reward. Monkeys and humans with OFC lesions tend to perseverate on the previously rewarded object and do not alter their behaviour in response to the non-rewarded object (e.g., Dias, Robbins, & Roberts, 1996; Jones & Mishkin, 1972; Roberts, 2006; Rolls et al., 1994).

Blair and Cipolloti (2000) also endorsed similar ideas in their social response reversal model which contends that the social difficulties of a person with frontal lobe injury stem from an inability to modify his or her behaviour in response to changing social cues. Social response reversal theory focuses on the ability to modify one's behavior based on the perception of social cues, in particular angry expressions. Noteworthy is the fact that the OFC is differentially activated when persons view angry faces, relative to sad faces (Blair, Morris, Frith, Perrett, & Dolan, 1999). However, persons who have sustained OFC injuries, demonstrate impairments at recognizing emotions such as anger, and disgust, and have problems in attributing anger, fear and embarrassment to story heroes (Blair & Cipolloti, 2000). This model seems plausible since angry expressions are crucial to the regulation of moral behavior as they signal that there is something wrong/disagreeable and a need for change in the current context (Potegal & Stemmler, 2010). This flexibility in social behavior allows humans to survive in societies because they are able to adapt to their behaviors to the overarching social norms, and rules of the groups.

Neural bases to decision making: The OFC

The OFC, as described above, appears to play a critical role in social and everyday decision making. Hence, an understanding of the architecture and the responsibilities of this region is critical in the study of social and emotional consequences following MHI.

The OFC is situated above the orbits in the ventral portions of the PFC (see Figure 2) and can be partitioned into five cytoarchitectonic sub-areas: the rostral polar area (Brodmann's area [BA]10), anterior area (BA11), caudal area (BA13), medial area (BA14) and lateral area (BA47 and 12) (Wallis, 2007). There are four sulci that separate the entire surface into five gyri. There are also three parallel sulci that are located along the anterior-posterior axis: the olfactory sulcus, the medial orbital sulcus and the lateral orbital sulcus (Chiavaras & Petrides, 2000). The major regions and sulci of the OFC are shown in Figure 2.

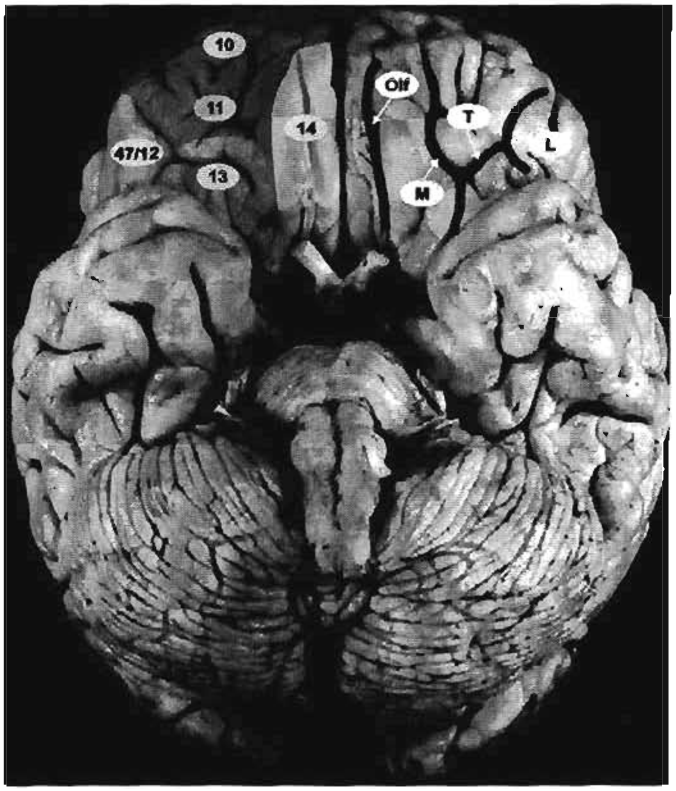


Figure 2. Ventral view of the human brain depicting the major regions of the OFC and its main sulci. Olf = Olfactory sulcus, M= medial orbital sulcus, T= transverse orbital sulcus, L=lateral orbital sulcus. Adapted from "Comparative Architectonic Analysis of the Human and Macaque Frontal Cortex" (pp. 17-57) by M. Petrides, M., & D.N. Pandya, 1994, in F. Boller & J. Graftman, (Eds.), *Handbook of Neuropsychology*, New York: Elsevier.

Outline of connections.

The connections of the OFC exhibit two main features which make it suited for decision making. Firstly, it is well positioned to receive information from the external environment because of its unique feature of having connections with all sensory modalities. Connectivity studies have shown that the gustatory and primary olfactory cortices including the anterior olfactory nucleus, olfactory tubercle and the pyriform cortex send inputs to the posterior regions of the OFC (Carmichael, Clugnet, & Price, 1994).Visual information is also transmitted to the caudal regions of the OFC via projections from higher order visual and polymodal association areas (Carmichael & Price, 1995). Similarly, auditory and somatosensory inputs are sent to this area from the secondary and tertiary auditory areas and the primary and secondary cortices, respectively (Romanski, Bates, & Goldman-Rakic, 1999).The OFC, in turn, sends projections out to these sensory and polymodal cortices (Cavada, Company, Tejedor, Cruz-Rizzolo, & Reinoso-Suarez, 2000).

The responses of the OFC neurons to sensory stimuli typically reflect the emotional valence (i.e., reward contingencies) of these stimuli and not their physical properties. In this regard, several human imaging studies have shown increased activity in the OFC in response to both rewarding and punishing stimuli presented in each of the sensory modalities of taste (O'Doherty, Rolls, Francis, McGlone, & Bowtell, 2001), odor (Rolls, O'Doherty, Kringelbach, & De Araujo, 2003), audition (Frey, Kostopoulos & Petrides, 2000) and vision (O'Doherty et al., 2003).

Secondly, the OFC, in general, and the posterior regions, in particular, are reciprocally connected with the cortical limbic areas in the anterior cingulate and medial temporal cortex and with the sub-cortical limbic structures such as the amygdala, mid-line thalamic nuclei, cingulate gyrus, and the magnocellular sector of the mediodorsal thalamic nucleus (Carmichael & Price, 1995; Davidson, Putnam, & Lawson, 2000). Through its connections with the amygdala, the OFC can influence the central autonomic structures in the hypothalamus and brain stem areas, such as the periaqueductal gray area – a parasympathetic structure responsible for the emotional "fight" or "flight" responses (Ongur & Price, 2000). These latter structures, in turn, innervate spinal autonomic structures which activate the peripheral autonomic organs, such as the heart and lungs, in order for them to increase their responses during emotional arousal.

In view of the above, the OFC integrates physiological arousal, emotional and reward information needed for instrumental learning and stimulus-reinforcement associations (Mishkin, 1964; Rolls, 2000), mechanisms underlying advantageous decision-making. In essence, the OFC modulates decision making by predicting the possible negative consequences and rewards associated with certain choices, thereby facilitating either 'approach' or 'withdrawal' behaviours. For example, a person will choose not to kill as a result of anticipating the negative emotional consequences that are associated with killing in the society (i.e., being ostracized or thrown in jail). In light of this, an injured OFC, for example as in E.V.R, could arguably predispose him to ignore the possible negative consequences of losing his entire savings or, similarly, individuals with early injuries to the PFC may fail to acquire moral values in line with their social context since the ability to associate the violation of these norms with negative emotional sanctions could be impaired.

In summary, the OFC can be viewed as an "executive" area of the PFC as it is situated within a neural network that allows it to regulate the body's emotional mechanisms for advantageous decision-making and social behaviour.

Neural bases to moral cognition: Neuroimaging data.

Recent brain imaging studies with healthy subjects also provide insights into the neural underpinnings of moral reasoning and judgment. Using functional magnetic resonance imaging (fMRI) techniques, four major studies have consistently revealed activity in several brain areas including the VMPFC during a variety of moral appraisal tasks.

One earlier, and influential, study in this area is Greene et al.'s (2001) distinction between 'personal' and 'impersonal' judgments. In this study, several dilemmas were used to determine the conditions under which moral transgressions were judged to be acceptable. Personal dilemmas were designed to elicit 'intuitive processing' and involved serious bodily harm to another person. Impersonal dilemmas included transgressions that involved no harm (e.g., stealing) or harm that resulted from unintentional means (e.g., a deflection of responsibility). The researchers found that reasoning about personal moral dilemmas (as compared to impersonal and non-moral dilemmas) stimulated greater activity in brain regions that are active during emotionally salient contexts, such as the medial frontal gyrus, posterior cingulate cortex (PCC), angular gyrus, bilateral and superior temporal sulcus. By contrast, impersonal dilemmas and non-moral dilemma generated greater activity in areas related to working memory, such as the dorsolateral prefrontal cortex (DLPFC) and bilateral parietal regions. Further, participants were slower in endorsing personal transgressions, but faster in disapproving them; whereas, reaction times were the same when approving or condemning impersonal and non-moral violations.

Greene et al. (2001) interpreted these findings as supporting a combination of the rational and emotionalist models of moral judgment. They proposed that the medial prefrontal cortex modulates the strong emotional aversion (i.e., guilt and regret from causing deliberate harm to a victim) to harming an individual, and, thus drives moral disapproval. Against this background, findings indicating that participants were quick to disapprove personal moral violations are in accordance with the emotionalist account of moral judgment. On the other hand, findings of a longer reaction time indicate the subjects must overcome their negative emotional responses to engage in cost-benefit reasoning (a rationalist account), which is supported by the DLPFC.

Since Greene et al.'s (2001) study, other studies have confirmed the activation of the medial frontal gyrus, frontopolar gyrus, PCC and posterior superior temporal sulcus (PSTS) during the evaluation of moral tasks. Moll, Oliveira-Souza, Bramati and Graftman (2002) used simple sentences that conveyed moral connotations (e.g., He shot the victim to death.) and feelings of disgust (e.g., Pregnant women often throw up.). They found that the left medial OFC and left temporal pole, and STS were activated for the moral condition while the left lateral OFC, ventral visual cortex and the left amygdala were recruited in the non-moral/emotional conditions.

While Moll and colleagues (2002) focused on the differential effects of moral versus non-moral judgments, Heekeren et al. (2005) specifically examined the neural correlates associated with the impact of bodily harm on semantic and moral decision-making. Using simple sentences that conveyed, or did not convey, bodily harm, they found that moral decisions generated increased activity in the VMPC, the right PCC, the PSTS and the temporal poles compared to semantic decisions. Subjects also responded faster to moral and semantic stimuli depicting bodily harm than those devoid of harm.

Finally, Berthoz, Grezes, Armony, Passingham, and Dolan (2006) investigated whether a person's judgment of the violation of social norms differed as a function of "who" is committing a transgression (i.e., 'Agent' – self versus other), as well as the "intentionality" of the violation committed (i.e., accidental or intentional). Participants were presented with several scenarios that were manipulated to depict the following transgressions: *'Self-Intentional'* - the participant intentionally transgressed a social norm; *'Self-Accidental'* - the participant accidentally transgressed a social norm; *'Other-Intentional'* - another person, apart from the participant, intentionally transgressed a social norm; and *'Other-Accidental'* - another person accidentally transgressed a social norm. They were then asked to evaluate the appropriateness of the agent's behaviours.

Significant activations in the left dorsolateral PFC, superior frontal cortex, anterior cingulate gyrus, left amgydala, right cerebellum and, bilaterally, in the precuneus (the medial surface of the superior parietal lobe) were found when the participant evaluated the scenarios depicting intentional transgressions as compared to accidental ones. Further, increased activity was found in the left precuneus and right cerebellum when participants evaluated the violations committed by themselves as compared to those committed by others. Moreover, participants rated the accidental violations (regardless of the type of agency) more favorably than intentional violations (Berthoz et al., 2006).

The above findings suggest that a select group of neural structures overlap with the VMPFC regions responsible for moral judgment thereby leading to the concept of the 'moral brain'. The brain areas comprising the 'moral brain' are illustrated in Figure 3.

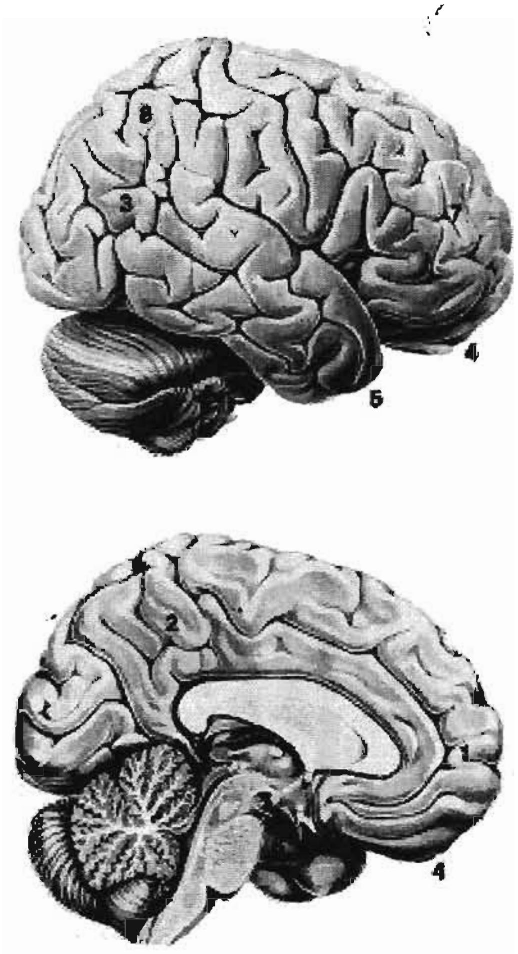


Figure 3. The 'Moral Brain' - Brain areas implicated in moral cognition by neuroimaging studies (Brodmann's areas in parenthesis): 1. Medial frontal gyrus (9/10), 2. posterior cingulated, precuneus, retrosplenial cortex (31/7), 3. Superior temporal sulcus, inferior parietal lobe (39), 4.

Orbitofrontal, ventromedial frontal cortex (10/11), 5. Temporal pole (38), 6. Amygdale, 7. Dorsolateral prefrontal cortex (9/10/46) and 8. Parietal lobe (7/40). Adapted from "Physiologie und anatomie der emotionen," by Adolphs, R., 2003 – *was in press at the time*, In H.O. Karmath & P. Thier, (Eds.), *Handbuch der Neuropsychologie (pp. 569-580).* Heidleberg: Springer-Verlag as depicted in J. Greene & J. Haidt, 2002, *Trends in Cognitive Sciences, 6*, 521.

Definition and diagnosis of MHI

While much of the literature has been focused on the social, cognitive and emotional consequences following moderate to severe brain injuries, these enduring effects in MHI, despite strongly debated in literature, have not been fully investigated. Little is known about the effects of having a history of mild head injury (MHI) on arousal levels and moral decision making, nor its relationship to one's own intentional violation of social norms. Hence in this thesis it was investigated whether moral decision making is similarly affected with mild injuries to the head,and the complex relationships between MHI, arousal and moral decision making in university students was explored. The following literature will discuss the definition, post-injury symptoms, and the short-term and long-lasting deficits in functioning for persons with MHI in order to provide a theoretical background for this investigation.

Although MHI can be considered a major health concern due to its high incidence rate, there is a lack of consensus surrounding its definition. For instance, the literature uses the term 'mild head injury' interchangeably with 'mild brain injury', 'mild traumatic brain injury (MTBI)', 'minor head injury', 'minor closed head injury' and 'concussion' (Mateer & D'Arcy, 2000). However, MTBI is the term preferred by the neuropsychological community since it captures the idea of the brain being injured (Kay, Newman, Cavallo, Ezrachi, & Resnick, 1992). Against this background, one of the most frequently used definitions of MHI is the one proposed by the Mild Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine (ACRM, 1993). According to this definition, an individual with a

MTBI is one who has had a traumatically induced physiological disruption of brain function as manifested by at least one of the following:

> (i) any period of loss of consciousness; (ii) any loss of memory for events immediately before or after the accident; (iii) any alteration in mental state at the time of the accident; and (iv) focal neurological deficit (s) that may or may not be transient; but where the severity of the injury does not exceed the following: (i) loss of consciousness approximately 30 minutes or less; (ii) after 30 minutes, an initial Glasgow Coma Scale (GCS) of 13-15 upon hospital admission and post-traumatic amnesia of not greater than 24 hours.
>
> (ACRM, 1993, p. 86)

From this definition, it becomes clear that a loss of consciousness is not a prerequisite to be diagnosed with a MHI.

The GCS (Teasdale & Jennett, 1976) is the most widely used criterion to assess clinical research and practice (Iverson & Lange, 2003). It is designed to evaluate depth of coma following a TBI and consists of three subscales: eye-opening (ranging from 1-4), motor response (ranging from 1-6), and best verbal response (ranging from 1-4), with 3 being the lowest possible score and 15 the highest. In light of this, an individual with a GCS score ranging from 13-15 can be diagnosed with a MHI. A GCS ranging from 3-8 can be classified as a severe head injury, while a score ranging 9-12 is indicative of a moderate injury.

Notwithstanding, recent research has shown that there may be some limitations when applying GCS in the diagnosis of MHI. For instance, a GSC score of 15 can indicate normal functioning following a MHI; while, on the other hand, this score may also indicate a transitory disruption in consciousness. Accordingly, this criterion in assessing MHI must be used with caution as patients may experience cognitive dysfunction owing to their injuries despite not having GCS scores less than 15 (Giza & Hovda, 2001).

Severity classification is also guided by the presence and length of postinjury loss of consciousness (LOC) and posttraumatic amnesia (PTA). PTA greater than 7 days and LOC of no greater than 24 hours is indicative of a severe head injury (Fletcher et al., 1995). Shorter durations (i.e., 30 minutes or less, between 30 minutes and 24 hours) of LOC and PTA (i.e., 24 hours or less, 24 hours to less than 7 days) are commonly related to milder or moderate head injuries (Levin et al., 1982).

Finally, injury evaluation is enhanced by imaging techniques such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Single-Photon Emission Tomography (SPECT). CT scans have been shown to detect small petechial hemorrhages that are associated with DAI in individuals with MTBI (Levi, Guilburd, Lemberger, Soustiel, & Feinsod, 1990). However, SPECT (Reba, 1993) and newer techniques such as DTI (Bigler, 2008) have been shown to have higher sensitivity than CT in detecting structural abnormalities especially in milder injuries.

Post-concussive Syndrome.

After sustaining a MHI, many patients experience a host of acute symptoms known as "post-concussive syndrome" (PCS). These symptoms include physical ailments (e.g., nausea, vomiting, confusion, disorientation, unsteadiness, dizziness, headaches, sleep difficulties, insomnia and insensitivity to noise and light), affective and behavioural changes (e.g., anger, depression, irritability, and social difficulties) and cognitive complaints (e.g., problems with concentration, perception, executive functions, memory and problem solving) (ACRM, 1993; Giza & Hovda, 2004; Sayegh, Sandford, &Carson, 2010).

Consistent with the interpretation that cognitive differences may persist following PCS, Smiths et al. (2009) correlated brain area activation during different types of neuropsychological testing for an average of 31 days postinjury in persons who experienced minor head injury and demonstrated no significant findings on CT taken 24 hours after impact. They found that as the neuropsychological effort increased for a working memory task (2 n-back) and attention task (STROOP), there was a corresponding increase in brain area activations as a function of PCS symptom severity.

The contributing factors to the development of these symptoms have long been debated in the field of neuropsychology (e.g., Ericksen, 1882 as cited by Rutherford, 1989; Oppenheim, 1889 as cited by Benton, 1989). For Ericksen (1882 as cited by Rutherford, 1989), these symptoms have a neurological basis while Oppenheim (1889 as cited by Benton, 1989) contended that they can be attributed to psychological factors. Various studies have provided support for psychological factors in the etiology of post-concussion symptoms (e.g. Iverson, 2006). For example, McCauley, Boake, Levin, Contant and Song (2001) found that increased levels of depression at one month post-injury were a risk factor in developing PSC at three months; and Mooney, Speed and Sheppard (2005) found that a history of psychological insult such as depression and chronic pain was related to outcome after MTBI. Finally, PCS in some individuals have been arguably linked to malingering and compensation-seeking (Lange, Iverson, Brooks, & Ashton Rennison, 2010).

Conversely, many other studies (e.g., Bigler, 2008; Giza & Hovda, 2001, 2004; Umile et al., 2002), as outlined above, have demonstrated a neurological basis for PCS. Together, these studies clearly indicate that neither psychological nor neurological factors alone have been accepted to fully explain the basis of the MTBI symptoms. Instead, Kay et al. (1992), and more recently Faux, Sheedy, Delaney, and Riopelle (2011), have proposed a multifactorial model which contends that a variety of neurological, psychological and environmental factors interact to drive the persistent symptoms of PSC.

Long and short-term sequelae of MHI

Several studies have indicated complete resolution of PSC symptoms in the majority of persons following MHI (e.g., Faux et al., 2011; Levin et al., 1987; McCrea et al., 2003; Rutherford, Merrett & McDonald, 1979). In one study of functional recovery of participants with MHI, Levin et al. (1987) found complete recovery within three months. Similarly, Rutherford et al. (1979) found that approximately 95% of individuals with MHI had full resolution of post-concussive syndrome at six months-one year post injury.

More recently, McCrea et al. (2003) used the Graded Symptoms Checklist (Lovell and Collins, 1998), Balance Error Scoring System (McCrea, Randolph, & Kelly, 2000) and the Standardized Assessment of Concussion (Guskiewicz, Ross, & Marshall, 2001) to investigate functional outcome after concussion and found that athletes returned to pre-injury function within seven days. Notwithstanding, researchers have argued that this "good' recovery may very well represent a behavioural adjustment instead of the actual regaining of previous functioning abilities (Segalowitz, Bernstein & Lawson, 2001).

Cognitive sequelae.

Despite the documented instances of short-term recovery, growing evidence indicates that a sub-group of individuals following MHI continue to show deficits in cognitive functions involving working memory (Baker & Good, 2009), processing speed (e.g., Bernstein, 2002), and divided and selective attention (e.g., Bohnen, Jolles, & Twijnstra, 1992). Broglio, Macciocchi and Farrera (2007) found that 35% of the college athletes who experienced a sports-related concussion (acquired through football, soccer, cheerleading, equestrian sports) continued to demonstrate neurocognitive impairment after they no longer reported experiencing concussion-related symptoms.

In one study that investigated the cognitive residua following MHI, Baker and Good (2009) administered a series of neuropsychological tests to evaluate cognitive impairments in university students with a history (two years) of self-reported head MHI. History of MHI was defined as a yes/no response to the question "Have you ever hit your head against a surface or object which altered your consciousness (e.g. loss of consciousness, vomiting, dizziness)?" Results indicated that students with MHI performed more poorly on neuropsychological measures of working memory (Trail Making Test, Delis, Kaplan, & Kramer, 2002; Digit Symbol-Copy task, Wechsler, 1997), and attention (Stroop Colour-Word Interference subtest, Delis et al., 2002) than non-injured students.

Consistent with these results, Bohnen et al. (1992) investigated the cognitive performance of individuals with persistent PSC (i.e., six years after injury) by administering a divided attention task and the Stroop Colour-Word Interference test (often referred to as Stroop). Diagnostic criteria for MHI comprised the following: PTA less than 60 minutes, LOC less than 15 minutes, a GCS score of 15 and the absence of any serious traumatic physical injury, while PSC was assessed using a checklist. Findings revealed that symptomatic persons performed poorly on the Stroop task, especially on the more challenging sub-test, compared to non-injured controls and symptom-free individuals. Further, symptomatic persons were significantly slower in their reaction time on the divided attention tasks relative to the other two groups.

Another study conducted by Bernstein (2002) found reduced information processing among university students with a history of self-reported head injury. Using event related potentials (ERPs) during the processing of two complex auditory tasks and several auditory discrimination tasks, it was revealed that MHI students had lower discrimination (d') on the former tasks and reduced P300 evoked potential amplitudes on the latter relative to their non-injured counterparts.

Emotional sequelae.

Empirical evidence has also accumulated indicating reduced physiological arousal among university students with MHI (e.g., Jung & Good, 2007; St. Cyr & Good, 2007, 2008). In their study, Jung and Good (2007) investigated the influence of psychological stress on cognitive performance in university students with a history of self-reported MHI. MHI diagnosis was consistent with the definition proposed by Kay et al. (1993). Findings indicated lower heart rate (HR) among MHI students compared to non-injured controls during a psychological stressor (e.g., presenting on several highly stress-provoking topics while being taped by camera). Additionally, MHI students demonstrated lower levels of self-reported anxiety as measured by the State-Trait Anxiety Inventory-2 (STAXI-2) (Spielberger, 1996). Further, MHI students with increased stress performed better on the Stroop task compared to their non-injured counterparts.

St. Cyr and Good (2008) generated similar results after examining the interacting effects of stress-anxiety and memory performance in university students with a history of MHI. Again, MHI criteria were similar to Kay et al.'s (1993) definition. Results indicated that MHI students had lower levels of self-reported state anxiety (Spielberger, 1996) despite reporting a higher number (and intensity) of stressful life events compared to non-injured controls. Additionally, MHI students who experienced higher levels of stress performed better on verbal memory tasks (Logical Memory I and II of the Wechsler Memory Scale-III (WMS-III) - Wechsler, 1997).

Conversely, students without a history of MHI performed poorer on these tasks when experiencing higher levels of self-reported anxiety.

Deficits in emotional recognition have also been noted in participants following MHI similar to those observed in individuals with more severe injuries (e.g., Blair & Cipolotti, 2000). For example, van Noordt and Good (2010) reported that university students with a prior history of MHI were significantly less able to recognize negative emotional facial expressions, particularly those involving anger, than participants without previous head injury.

These findings suggest that individuals with a history of MHI present with reduced arousal levels and will be less sensitive to the emotional significance of stimuli. Counterintuitive, increased arousal seems to confer cognitive benefits with respect memory for university students with a history of self-report MHI.

Moral sequelae.

Finally, it has been demonstrated that university students with a history of MHI make different moral decisions compared to non-injured controls. Using the Social Problem Solving Inventory-Revised (D'Zurilla, Nezu, & Maydeu-Olivares, 2002) and Greene's et al. (2001) personal and impersonal test, Chiappetta and Good (2010) found that MHI participants viewed themselves as equally competent at social problem solving but were more likely than non-injured controls to endorse personal violations and were faster doing so. Moreover, MHI participants did not differ in their response times to personal and impersonal dilemmas. These findings are consistent with the interpretation that individuals with mild trauma may be less likely to use or have available emotional/physiological cues, which are modulated by the OFC/VMPFC, to inhibit less conventional choices. As discussed above, the OFC/VMPFC regions are susceptible to injury in MHI and can lead to disruption in neural communication with the hypothalamus, amygdala, and brain stem regions such as the periaqeductal grey – areas (Carmichael & Price, 1995; Davidson, Putnam & Lawson, 2000). Consequently, individuals with MHI may be physiologically underaroused which, in turn, may predispose them to make choices that have immediate and utilitarian benefits.

Rationale for the Study

As noted before, recent work by Chiappetta and Good (2010) using Greene et al.'s (2001) moral dilemmas has revealed the willingness of individuals with MHI to engage in personal violations that lead to utilitarian outcomes. However, close scrutiny of these materials has revealed some challenges in terms of the type of harm caused by each transgression within the impersonal and personal dilemmas. More specifically, impersonal dilemmas included both bodily harm and non-physical harm outcomes committed in an unintentional manner and personal dilemmas included both bodily harm committed unintentionally and deliberately, as well as non-physical harm outcomes. These variations are meaningful as they were found to be correlated with physiological arousal in *post hoc* analyses, thereby, providing evidence for the influence of somatic feedback on decision-making.

In short, past research did not control well for the type of harmful outcome that a moral transgression will produce and, thus, it is unclear how the neural and behavioral correlates of moral decision-making are modulated. Hence, the present research was designed to replicate and extend Chiappetta and Good's (2010) work by investigating moral decisions as a function of MHI using modifications of Greene's stimuli (Greene et al., 2001; Greene, Nystrom, Engell, Darley, & Cohen, 2004). The stimuli were adapted and, as needed, restructured to depict three types of transgression outcomes: physical harm, non-physical harm and no-harm.

In addition, given the importance of 'intention' on moral and social decision making (e.g., Berthoz et al., 2006), the scenarios were written in such a way as to describe two different levels of the agent's intention: acts will be produced in a deliberate or accidental manner. Also examined in this study was whether individual differences in cognitive skills, physiological responsivity, and social reasoning are related to the kinds of decisions made by participants with and without a history of MHI.

In order to investigate this problem, we chose to assess a group of competent individuals with a history of MHI (university students) since they have been found to exhibit subtle emotional, physiological and behavioural deficits despite their adequate intellectual capacity. In this manner, there is less concern that the decisions made by these students are a function of being uninformed or less than optimal problem solving abilities. In addition, there is evidence university population is an ideal group to study because there is an expectation that there will be substantial representation of subjects having sustained a previous MHI (Yeates & Taylor, 2005; Segalowitz & Lawson, 1995). The investigation of this particular individual difference could shed light on the question of whether individuals with mild head trauma exhibit the same neurobiological profile as those with moderate to severe injury to the OFC/VMPFC areas.

We also collected physiological data that included eletrodermal activity, EDA, HR and respiration while participants respond to a modified version of Greene et al.'s (2001) moral dilemmas. This was due to the tenets of somatic marker hypothesis, which proposed that physiological responses influence decision making in situations of uncertainty (Damasio, 1996; Damasio, Grabowski, Frank, Galaurda, & Damasio, 1994). The rationale for using each of these measures is described hereunder.

Electrodermal Activity (EDA).

The changes in the electrical conductance of the skin during the processing of affective and physical stimuli are referred to as EDA. EDA is assessed by placing a pair of electrodes on the fingers of one hand and applying an imperceptible current across the electrodes. EDA variation reflects states of arousal and alertness (Scarpa & Raine, 2003) and is determined from the sympathetic nervous system innervations (primarily cholinergic fibres) of eccrine sweat glands (Dawson, Schell, & Filion, 2007). As such, EDA provides a non-invasive index of sympathetic arousal that taps states of arousal, attention and emotional processing. Moreover, EDA has an advantage over other indices of autonomic nervous system such as HR because it is under precise control of the sympathetic branch of the autonomic nervous system (Dawson et al., 2007).

Heart Rate (HR).

HR is another psychophysiological measure of autonomic responses to novel or affective stimuli. Changes in heart rate reflect sympathetic and parasympathetic nervous system activity and can be evaluated tonically (i.e., beats per minute at rest) and phasically (i.e., alteration in response to an event) (Scarpa &Raine, 2003). A major benefit in using HR measures is that the deliberation of change (acceleration or deceleration responses to stimuli) can be interpreted in terms of a balance between sympathetic and parasympathetic nervous activity (Skwerer et al., 2009). HR acceleration is related to the processing of aversive events (i.e., an index of defensive reactions) or to the anticipation of a stimuli, that necessitates cognitive elaboration (Lacey, 1967 as cited in Skwerer et al., 2009) while HR deceleration is associated with attentional shifts (i.e., orienting or alerting responses) (Binder, Barry, & Kaiser, 2005 as cited in Skwerer et al., 2009).

Respiration.

Respiratory activity is determined both from central nervous system activity and homeostatic mechanisms. In this regard, changes in the breathing patterns (reflective of alternations of oxygen and carbon dioxide homeostasis and sympathetic activity) have been used in studies of emotion and affective processes. For example, altered respiratory activity (e.g., depth of inspiration breathing and breathing rate) vary across different emotive states such as anxiety, laugher and anger (Timmons & Ley, 1994). In addition, reduced respiratory rates have been related to attenuated EDA or cardiovascular activity in stressful situations (Cappo & Holmes, 1984; Grossman, 1983). Thus, respiratory activity will be used as a complement measure of physiological arousal to EDA and HR during the evaluation of the moral dilemmas.

Hypotheses

In the current study, it was expected that individuals with a history of MHI will generate lower levels of arousal as indicated by self-report ratings and physiological indices such as EDA, HR and respiration compared to those who do not report experiencing a previous MHI. Consequently, MHI individuals will rely more on the cognitive appraisal of moral dilemmas and less on physiological feedback and, therefore, will engage in less conventional decisions than their non-injured cohort. In general, the following questions will be examined.

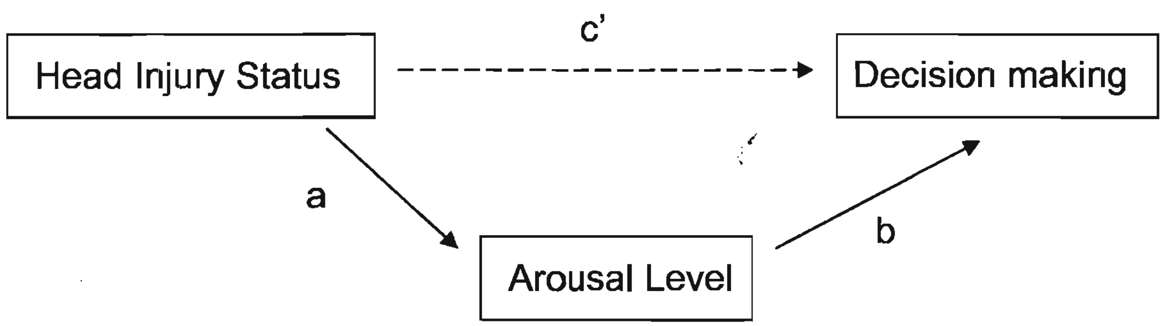
1. **Is there a relationship between arousal levels and a history of MHI?** Due to the role of the orbitofrontal and ventromedial prefrontal cortices in regulating physiological and emotional feedback and their particular vulnerability in traumatic brain injuries (Mayer & Schwartz, 1993; Ongur & Price, 2000; Umile et al., 2002), *it was expected that participants who report a history of MHI would be more likely to demonstrate reduced levels of arousal on physiological and self-report measures during baseline and during decision making performance compared to non-MHI participants.*

2. **Will participants who report a history of MHI differ from non-MHI participants in their decisions and response time on moral dilemmas?** Individuals with both severe and mild frontal lobe injuries differ from non-injured controls by engaging in utilitarian decisions due to the role of VMPFC/OFC in failing to modulate the emotional responses which can bias individuals away from these less conventional choices (Mishkin, 1964; Rolls, 2000). In addition, previous studies have indicated that the evaluation of moral violations is dependent on whether the violation was committed unintentionally or deliberately despite incurring the same physical consequences (Baird & Astington, 2004). In keeping with this, a three-way interaction (head injury status x dilemma outcome x intentionality) was predicted such that persons with MHI (who have less physiological and emotional feedback) would be less aversive to conflicts in moral dilemmas than their non-MHI counterpart. More specifically, it is hypothesized that *participants with a history of MHI would rate themselves as more likely to report that they would commit moral violations independent of the intentionality (deliberate or unintentional) and outcome (physical harm, non-physical harm, no harm) of the dilemma, and would do so more quickly, than their non-MHI counterparts.*

3. **Will sympathetic arousal mediate the relationship between MHI and moral decision-making?** As noted, empirical evidence has indicated that individuals with focal frontal lobe injuries are less emotionally responsive and, more specifically, lack the ability to generate and use 'somatic markers' to guide decision making on the IGT task (Bechara et al., 2000; Eslinger & Damasio, 1985). It is possible that incurring a MHI may impede the ability to process and use 'somatic markers', which in turn, results in impaired decision making. Consistent with this, *it was expected that a history*

of MHI would be associated with/result in reduced arousal levels and it is this lowered physiological feedback that influences one's decision making. Therefore, MHI status would be indirectly related to decision making as a function of physiological arousal. This model is illustrated in figure below.

Figure 4. Mediation Model Depicting the Relationship Among MHI Status, Arousal Levels and Moral Decision making



4. **Will a history of MHI be related to poorer executive functioning and outcomes of decision making?** Participants who have sustained injury to frontal cortices have been shown to variably perform less well than their age-matched cohorts on tests of executive functioning (particularly tests of working memory, attention and cognitive flexibility) (Baker & Good, 2009)). Since limits on these executive functioning skills can effect one's ability to anticipate, consider multiple variables/scenarios/outcomes simultaneously, or appreciate alternative perspectives simultaneously, they can also place limits on one's ability to evaluate (Rolls, 2000; Rolls et al., 2003; Stuss et al., 200;) and judge complex problems and can, therefore, influence their performance on decisions made to moral dilemmas. In light of this, *it was expected that MHI participants would be more likely to perform poorly on test of executive functioning that tap cognitive flexibility, working memory and attention when compared to non-MHI participants, and may be reflected in differences in moral decision making.*

5. Past findings have shown that individuals with a history of MHI report experiencing PCS more often, with increased intensity and for longer durations (Gouvier et al., 1992; Baker & Good, 2009) as compared to non-injured controls. In line with this, *it was expected that this finding would be replicated.*

Method

Participants

Forty-eight students enrolled at Brock University were included in our study (24 MHI, 24 No MHI). Since MHI status was unknown until participation in the research was complete, 88 students were originally tested in order to obtain 24 students who reported a previous head injury. Recruitment for participation was carried out in accordance with the Research Ethics Board (REB) procedures: through posters placed throughout the university, Brock University Psychology Department's SONA system, and from invitations extended to several classes. In order to prevent the influence of head injury identification (known as "diagnosis threat") on decision-making, there were no selection criteria for this individual difference (Suhr & Gunstad, 2005).

Students were eligible for the MHI group if they had answered in the affirmative to the question "Have you ever hit your head against a surface or object which altered your consciousness (e.g. loss of consciousness, vomiting, dizziness etc)?" (Kay et al., 1993). Of the original sample, 29 (33%) participants reported incurring a MHI. However, 1 participant was excluded from the analysis as her injuries were classified as severe (due to a stroke) while an additional 4 participants were dropped as they had incomplete or corrupted data for the relevant variables. Twenty-four non-MHI participants (40.7%) were selected on the following basis: (a) order of testing (such that students tested first were included if they fit the following additional criteria); (b) having a complete/noncorrupt data file for each of the test variables (this was a particular concern for physiological measures); and (c) matched to MHI on age and education, as well as assignment to one of the four counterbalance orders (ideally, N=6 per order). Note, overall there were no significant differences between the 48 participants (24 MHI, 24 No MHI) and the 40 non-participants (5 MHI, 35 No MHI) for educational level, χ^2 ($df = 2$, $N = 88$) = .712, $p = .70$, and age, $F(1, 86) = 1.36$, $p = .245$. However, the groups differed by gender, χ^2 ($df = 1$, $N = 88$) = 3.62, $p = .05$, such that there were more males than females in the participant group.

The final sample for the study consisted of forty-eight (54.5% of the total group identified) participants (29 females, 19 males, $M_{age} = 20.63$ years, $SD = 2.98$, range: 18 - 29 years) and included first (27.1%) and upper year students (i.e., second year, 12.5%; third year, 20.8%) who majored predominantly in Psychology (31.3%) and Kinesiology (14.6%). Participants included in the analysis were randomly assigned to one of the four counterbalanced moral dilemma conditions: Order 1 ($n = 14$), Order 2 ($n = 12$), Order 3 ($n = 10$) and Order 4 ($n = 12$) (refer to Appendix B: Table 1). No differences were observed across these orders with respect to sex, level of education, and age: χ^2 ($df = 3$, N = 48) = 5.45, $p = .141$; χ^2 ($df = 6$, $N = 48$) = 6.72, $p = .348$; and $F(3, 28.82) = .313$, $p = .816$[1], respectively. As shown in Table 2, the MHI and No MHI participants did not differ on a variety of demographic and medical history variables. The majority of the participants were right-handed (89.6%; MHI, $n = 20$, No MHI, $n = 23$).

Of the final sample, 24 (50%) ($M_{age} = 21.21$ years, $SD = 3.00$ years, age range: 18-28 years, 13 females, 11 males) students reported incurring a MHI. The mean age at time of head trauma

1 Brown-Forsythe test

was 14.78 years (*SD* = 4.12, range: 3-20 years) and average length of time since this head injury was 5. 87 years (*SD* = 4. 20 years, range: 8 months - 16 years).

There were 24 (50 %) non-injured controls who were on average, 20.04 years old (*SD* = 2.89 years), with an age range of 18 to 29 years. Of the non-injured participants, 16 were females and 8 were males. Informed consent was obtained from the participants and they were given research participation credit for their efforts.

Table 2

Summary Statistics for Demographic and Medical Characteristics for Participants with MHI and No MHI

	MHI (n = 24)		No MHI (n = 24)		
	n	%	n	%	χ^2 (df); p
Gender					7.84 (1); .376
Female	13	54.2	16	66.7	
Male	11	45.8	8	33.3	
Education					7.84 (1); .376
High school graduate	6	25.0	6	25.0	
College graduate	2	8.3	1	4.2	
1st year university	5	20.8	8	33.3	
2nd year university	2	8.3	4	16.7	
3rd year university	8	33.3	2	8.3	

4^{th} year university	1	4.2	1	4.2	
Handedness					2.54 (2); .280
Right	20	83.3	23	95.8	
Left	2	8.3	1	4.2	
Both	2	8.3	0	0.0	
History of hospitalization complications					
Surgery	6	25.0	8	33.3	0.54 (1); .464
Illness	12	50.0	5	20.8	4.06 (1); .044*
Fractures	10	41.7	2	8.3	7.11 (1); .008**
Neurological	1	4.2	1	4.2	0.97 (1); .322
Diagnosis of:					
Neurological	1	4.2	1	4.2	2.00 (2); .368
Psychiatric	2	8.3	1	4.2	0.35 (1); .551
Medication for psychiatric or neurological	2	8.3	0	0.0	2.08 (1); .149
Age (years)					1.87 (1, 46); .178
M (SD)	21.21	(3.00)	20.04	(2.89)	

***p < .05; *p < .01**

Materials and Stimuli

Individual differences questionnaires.

Individual differences were evaluated in terms of health, social problem solving styles (using the Social Problem Solving Inventory-Revised - SPSI-R; D'Zurilla et al., 2002), and arousal state.

Health status: Demographic questionnaire.

Health status was assessed in terms of the cognitive, physical and emotional concerns related to head injury using the Brock Neuropsychology Cognitive Research Laboratory Demographic Questionnaire (BNCRLDQ, 2009; refer to Appendix A3). Of particular interest was participants' self-reported status of previous traumatic head injury as determined by answering the following question: "Have you ever hit your head against a surface or object which altered your consciousness (e.g. loss of consciousness, vomiting, dizziness)?" As well, information regarding the history of a MHI, severity of the injury, age at injury and time post-injury were obtained. Participant's demographic characteristics such as sex, age, education, handedness, and history of drug use were also collected.

Health status: Post-Concussive Symptoms Checklist (PCSC).

Post-concussion syndrome was assessed using the Post-Concussive Symptoms Checklist (PCSC) (Gouvier, Cubic, Jones, Brantley & Cutlip, 1992) (see Appendix A4). This measure consisted of nine symptoms that are usually associated with post-concussion syndrome: headaches; dizziness; irritability; memory problems; difficulty concentrating; visual disturbance; aggravation by noise; judgment problems; and anxiety. Subjects were asked to rate the frequency, intensity and duration of each symptom on a 5-Point Likert type scale ranging from 1 (not at all) to 5 (all the time). Each participant received four types of scores: frequency total, duration total, intensity total and a general total score.

Gouvier et al. (1992) administered the scales to 100 undergraduate students enrolled in an introductory psychology course at two different time points (time-1 and time-1 plus two months) in order to develop the PCSC. The sample consisted of 50 MHI participants and 50 non-injured controls, all ranging in age from 18-24 years. Time-1 was defined as 24 hours post-injury for the MHI participants. Evidence for convergent validity was found as the four symptoms scores correlated well with those from the Postconcussion Checklist (Oddy, Humphrey & Uttley, 1978). Regarding discriminant validity, univariate analysis revealed that the head injured students endorsed significantly more symptoms than their non-injured counterparts at 24 hours ($p < .001$) and at two months post-injury ($p < .005$).[2] Evidence for internal consistency in our sample was found as indicated by the following reliability coefficients (Cronbach's alpha) for each of the four scales: total (.92); frequency (.79); intensity (.75); and duration (.71).

Individual differences: Verbal self-report of perceived arousal state.

Participants' current perceived state of arousal was assessed by asking the question, "On a scale ranging from 1 (very relaxed) to 10 (very stressed), how stressed are you now?" prior to administration of Moral Decision making Task and several times throughout the testing session.

Executive Function measures

Executive functioning abilities were assessed in terms of working memory, abstract reasoning, cognitive flexibility, attention and problem-solving styles using: the Letter-Number Sequencing subtest from the Wechsler Adult Intelligence Scale – III (WAIS III) (Wechsler, 1997), the Pictorial Analogies subset from the Comprehensive Test of Non-verbal Intelligence (CTONI) (Hammil, Nils, Pearson, Lee & Wiederholt, 1996), Trails Letter-Number Switching

2 (Note to committee: these symptoms are assessed as of a function of current experience – i.e. the day of testing: with this restricted time period, it has been shown in our lab to demonstrate differences between students who have a history of MHI and those who do not).

subtest from the DKEFS (Delis et al., 2002), the Stroop Colour-Word Interference subtest from the DKEFS (Delis et al., 2002), and the Social Problem Solving Inventory-Revised (SPSI-R; D'Zurilla et al., 2002).

Executive Function measures: Mental Control.

The Mental Control (WAIS-III, 1997) measure is designed to assess working memory and the ability to manipulate information 'online'. In this task, participants were asked to perform a series of sequencing tasks (e.g., numbers1-20, letters of the alphabet, and days of the week and months of the year) as quickly as possible in sequential order. Afterwards, they were asked to reproduce these tasks in the reverse order (e.g., count backwards from 20 and say the months of the year backwards). Of particular interest was the switching task which required participants to count by sixes while saying the days of the week in order. A stopwatch was used to record the time (in seconds) of the participant's response. Accuracy was also recorded.

Executive Function measures: Pictorial Analogies Test (CTONI, 1996).

The measure is designed to evaluate abstract reasoning skills, problem solving and complex decision making. For this task, participants were presented with four quadrants in which two of the four quadrants contain pictures depicting an analogous relationship. One of the remaining quadrants is left blank while the other quadrant displays a picture that has the potential of forming a similar analogous relationship. Participants were required to match the target picture selecting one of five choices to reflect the previous pair. Reponses must occur within 30 seconds and this was recorded with a stopwatch. Accuracy of responses was also recorded.

Executive Function measures: Trail-Making (DKEFS, 2002).

This is a timed paper and pen measure designed to assess sustained attention, working memory, sequencing and cognitive flexibility. Participants were required to locate and relate numbers and letters in an alternating sequence (as fast as possible) while keeping the ascending and alphabetical order constant (e.g., 1-A-2-B, etc). The accuracy and time (in seconds) of the participant's response were recorded using a stopwatch.

Executive Function measures: Stroop Color-Word Interference Test (DKEFS, 2002).

This measure is designed to assess cognitive flexibility, behavioural inhibition, and selective attention while being timed for speed of completion. Participants were given all four conditions; however, of particular interest was the inhibition task. Participants were presented with the names of several colors and then asked to name the ink color without reading the word itself. The number of errors and time of the participant's response were recorded using a stopwatch.

Executive Function measures: Social Problem Solving Inventory-Revised (SPSI-R; D'Zurilla et al., 2002).

This is a self-report inventory used to measure social problem solving abilities. It consists of 52 items with five subscales that measure five dimensions in the D'Zurilla et al. (2002) social problem- solving model. These are as follows: i. Positive problem orientation (10 items, e.g., "Whenever I have a problem, I believe that it can be solved"); ii. Rational problem solving (20 items, "I spend too much time worrying about my problems instead of trying to solve them"); iii. Negative problem orientation (10 items, e.g., "When my first efforts to solve a problem fail, I get very frustrated"), iv. Impulsivity/carelessness style (10 items, e.g., "When making decisions, I do not evaluate all my options carefully enough"); and v. Avoidance style (7 items, e.g., "I spend more time avoiding problems than solving them"). High scores on the positive problem orientation (PPO) and rational problem solving (RPS) and low scores on negative problem orientation (NPO), avoidance style (AS) and impulsivity/carelessness (ICS) are indicative of adaptive social problem solving ability (D'Zurilla & Chang, 1995). High scores on NPO, AS and ICS and low scores on PPO and RPS indicates poor problem solving ability. Additionally, the RPS subscale is further sub-divided into four subscales that assess four main problems solving skills (each containing 5 items): i. Problem definition and formulation (PDF); ii. Generation of alternative solutions (GAS); iii. Decision making (DM); iv. Solution implementation and verification (SIV). Participants completed this measure by using a 4-Point Likert scale ranging from 0 ("not at all true of me") to 4 ("extremely true of me").

Empirical studies of the SPSI-R's psychometric properties have found evidence for reliability and construct validity. For example, Kant, D'Zurilla, and Maydeu-Olivares (1997) administered the SPSI-R to 1020 (540 females and 480 males) college students enrolled in an introductory psychology course and who had an average age of 18.9 years. Results demonstrated internal consistency for the sub-scales as the following Cronbach's alphas were obtained: PPO (.76); NPO (.84); RPS (.87); PDF (.81); GAS (.77); DM (.75); SIV (.76); ICS (.74); and AS (.75). Similarly, in our study the following Cronbach's alphas were found: PPO (.80); NPO (.92); RPS (.93); PDF (.82); GAS (.80); DM (.78); SIV (.69); ICS (.88); and AS (.78). Further, test-retest analysis was conducted by Kant and colleagues (1997) using data from 138 participants tested over a three-week period obtaining the following reliability coefficients: PPO (.72); NPO (.88); RPS (.82); PDF (.75); GAS (.74); DM (.73); SIV (.74); ICS (.78); and AS (.78).

D'Zurilla and Nezu (1990) documented evidence of concurrent validity for the SPSI-R. Findings reveal that all of the SPSI-R scales except the PPO and RPS correlated positively with the subscales of Problem Solving Confidence, Approach Avoidance Style and Personal Control, subscales of the Problem-Solving Inventory (PS1; Heppner, 1988). Finally, D'Zurilla and Nezu

(1990) also found that none of the SPSI-R scales were significantly related to academic aptitude ($r = -.29$, $p < .01$), thereby indicating that the construct measured by SPSI-R did not overlap with general intelligence.

Physiological response measures

Physiological response measures were evaluated in terms of heart rate (HR), electrodermal activity (EDA) and respiration by using Limestone Polygraph Professional Suite software (Limestone Technologies Inc., 2007) and a 16" Acer laptop computer.

Physiological response measures: HR, EDA, respiration.

Prior to the decision making task, three minutes of baseline recordings of HR was obtained. During this task, HR was continuously recorded using a pulse oximeter attached to the middle phalanges of the non-dominant hand. Anticipatory HR was recorded for the 5 seconds prior to the onset of each successive dilemma and before the presentation of the Verbal Self-report of Perceived Arousal State measure. Onset HR was recorded from the onset of the dilemma and for the duration of it being read by the participant. Response HR was then collected while the participant responded to the dilemma or the Perceived Arousal State rating question followed by a reactionary HR which was collected during 3 seconds after the response made by the participant to the dilemma or to the Perceived Arousal State measure. All were measured as a function of frequency in cycles per minute.

Electrodermal activity (EDA) was also continuously recorded using metal electrodes placed on the palmar surface of the index and fourth fingers of the non-dominant hand; as was respiratory activity (via placing pneumographs, i.e., rubber electrodes, across the participant's chest and abdominal area). These measures were collected during the same epochs as described for HR (i.e., anticipatory epoch, onset epoch, reactionary epoch). Respiration was not analyzed owing to technical challenges posed by the polygraph equipment. Measures for each of EDA and respiratory activity were amplitude, measured in kilo-ohms (kΩ), and frequency, measured in cycles per minute, respectively. The software detected the amplitude of EDA occurring from the minimum to the maximum point within each epoch. In addition, the frequency of each measure occurring for each cycle per minute within each epoch was assessed. Finally, the mean response frequency and amplitude were calculated within each epoch and, after screening for artifacts, used as the dependent variables.

Moral decision making stimuli: Scenarios.

Decisions were assessed by the moral decision-making task (see Appendix A5) adapted from scenarios originated by Green et al. (2001). This task consists of scenarios which depict (a) one of two types of moral dilemma – either (i) deliberate transgression or (ii) unintentional transgression; (b) resulting in one of three types of outcome (i) physical harm, (ii) nonphysical harm, or (iii) no harm/no moral dilemma. Therefore each dilemma involves an agent (i.e., described as the participants themselves) engaging in a course of action who will deliberately, or unintentionally, bring about a particular outcome. Physical harm outcomes involve serious bodily harm to an individual, while non-physical harm outcomes involve transgressions against another (e.g. stealing money, but not causing physical harm to that person). Non-moral outcomes are those that have no moral dilemma presented.

Thus, participants read a total of 24 scenarios depicting six types of dilemmas (N = 4 each): (i) *unintentional physical harm* (e.g., hitting a switch to divert a trolley away from five persons towards a bystander person, and ultimately causing the death of this person.); (ii) *deliberate physical harm* (e.g., altering the medication of an individual who has vowed to infect others with a deadly disease thereby killing him); (iii) *unintentional non-physical harm* (e.g., confidential information valuable to investors is left unattended and a friend walks in your office, sees them and uses them to his or her advantage in the stock market); (iv) *deliberate non-physical harm* (e.g., reporting certain personal expenses as business expenses in order to lower one's taxes); (v) *unintentional non-moral* (e.g., administering CPR to bystander caused you to take the train instead of the bus); and (vi) *deliberate non-moral* (e.g., deciding between two coupons to use at the bookstore). Participants were asked to rate the likelihood of committing a transgression on a 5-point Likert type scale ranging from 0 (*Not at all*) to 4 (*Certain*). Primary measures of interest were response time (in ms) and the ratings provided by participants. The dilemmas were presented on a Macintosh iBook PowerPC in the form of a PowerPoint presentation.

Moral decision making stimuli: Self-report of justification for moral decisions.

At the end of the testing session, participants were asked to provide justifications for their decisions regarding two dilemmas. (i.e., "Preventing the Spread" and the "Standard Trolley") from the Moral Decision Making Task. These dilemmas were chosen because they capture the difference between 'unintentional' and 'deliberate 'violations. They completed this measure by briefly answering the following question, "How did you arrive at your answer for this dilemma?" Participants' answers were coded using aspects of Hauser et al.'s (2007) coding scheme: (i) sufficient justification; (ii) insufficient justification – deontological and utilitarian explanations acknowledged; (iii) insufficient justification – deontological explanation only; (iv) insufficient justification – utilitarian explanation only; (v) insufficient justification – "gut feeling"; and (iii) discountable justification. A sufficient justification accurately identifies any factual disparity between the two scenarios and acknowledges these differences as the basis for moral decisions. Conversely, an insufficient justification fails to identify a factual difference between the two scenarios (e.g., "I don't know how to explain it."), but acknowledges an explanation that either provides deontological, utilitarian, or both, reasons for their rating or refers to a 'gut feeling'/feels right vague reference. Finally, a discountable justification involves responses that are either blank or provide assumptions that are discounted (e.g., "a man's body cannot stop a train").

Procedure

Upon arrival at the laboratory, the participants were met by the researcher and commended for their willingness to participate in the study. Participants were told that the purpose of the study was to examine the influence of several indicators of individual differences (e.g., personality, arousal levels, and cognitive skills) on moral decision-making. Additionally, they were told that they would complete several questionnaires and a decision making task while their HR, EDA and respiratory activity are recorded. Immediately following the procedures establishing consent, the researcher prepared the participants for the application of the electrodes, oximeter and pneumographs. Participants' hands were first cleansed with sanitary wipes. Application took at most 5 minutes, while the participants' feedback regarding their comfort level or concerns with the equipment were addressed.

Before the participants were tested, the procedures of physiological data collection were described and shown to them. During this time, they were instructed to relax and remain as still as possible throughout the recordings and the experimenter recorded 3 minutes of EDA, HR and respiratory baseline activity.

The participants were introduced to the moral dilemma stimuli, which was presented by the computer screen placed on the table approximately 12 cm away. After focusing on a fixation cross for at least 2 seconds and a green screen that signaled 5 seconds of anticipatory recordings, each dilemma appeared one slide at a time and was read aloud (via a recording on the computer) to the participant at a pace of 145 words per minute using power point recording applications (Microsoft Power point, 2007). The PowerPoint recordings were used to control each participant's exposure to the material. After the stimuli had been presented, a second slide posed the question about the likelihood of engaging in the action described in that scenario (e.g., 'How likely would it be that you would carry out this particular course of action?') and they indicated their response by key press. Participants then focused on a blue screen that imputed a 3-second delay (permitting reactionary recordings). The stimuli were advanced using an 8-second inter-trial interval (ITI) before presentation of the next dilemma. A practice scenario was introduced in order to familiarize the participants to the procedure.

Notably, the scenarios were presented to the participants in a series of six blocks of four (Latin-square counterbalanced) trials according to the following order: unintentional non-moral; deliberate non-moral; unintentional non-physical; deliberate non-physical; unintentional physical; and deliberate physical. Essentially, each participant was randomly assigned to one of four different versions of the stimuli whereby each dilemma occurred once at each ordinal position, and preceded and followed every other dilemma only once. Further, each block of stimuli presentation was followed by an interval of 13 seconds for anticipatory responses and the completion of the verbal self-report of the perceived arousal state measure. All participants received the 24 dilemmas in a single session which lasted approximately 30 minutes. The Visual Basic for Applications program (using PowerPoint) recorded the time from the onset of the dilemma until the participants made a response.

Following the completion of the moral dilemma stimuli, the electrodes were removed from the participants and their hands were cleansed with sanitary wipes. After a 5- minute rest period, participants completed the Self-report of Justification task which lasted for 3 minutes. Then, the neuropsychological tests were administered in the following sequence: 1. Mental Control, 2. CTONI, 3.Trails, 4. Stroop. The sequence was maintained across all subjects in order to hold constant the amount of fatigue and cognitive load derived from each successive test. Prior to the administration of each neuropsychological test, the experimenter provided the participants with the relevant instructions. A total of 20 minutes were spent on the completion of these tests.

After this, participants were given the Social Problem Solving Inventory-Revised, the Demographics questionnaire, and the Post-Concussive Symptoms Checklist to complete. These took approximately 15 minutes. Following this, the participant was debriefed and thanked for his or her participation in the study. The entire session for each participant took approximately 1.5 hours.

Data Analysis

These data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 18.0. (2010). Assumptions regarding all analyses were explored, discussed and where applicable, the appropriate tests (e.g., Greenhouse-Geisser) to correct for violation (e.g., homogeneity of variance, sphericity) was used. A p-value of < 0.05 was considered to be significant for all analyses.

Preliminary analyses (e.g., ANOVA, Chi-square) focused on determining any group differences on demographic, pre-injury medical, educational and psychosocial variables that might influence subsequent performance on the relevant measures (e.g., moral ratings, executive function). Repeated mixed model ANOVAs, t-tests, and one-way ANOVAs were then conducted to address group differences for the primary dependent variables: self-reported measures of arousal; ratings and response times to moral dilemmas; and physiological arousal during the decision making task. In addition, Chi-square statistics were used to examine the effects of group differences on physical versus non-physical moral ratings. Separate t-tests and one-way ANOVAs were conducted for each domain of the cognitive measures and for the PCS variables. Non-parametric statistics were used where conservative post-hoc analyses for PCS measures were appropriate.

Hierarchical regression analyses were performed to examine the relative contributions of physiological arousal variables, executive functioning, and MHI history to predicting performance on the moral decision making task. Order of entry for the variables was theoretically driven. For this model, physiological variables were entered on the first step as these variables have been shown to influence decision-making (Bechara et al., 2000). Executive functioning measures were entered on the second step as one's ability to anticipate, consider multiple variables/scenarios/outcomes simultaneously, or appreciate alternative perspectives simultaneously, could place limits on one's ability to evaluate (ref) and judge complex problems and can, therefore, influence performance on decisions made to moral dilemmas. Finally, MHI history was entered on the third step since it was the aim of the study to ascertain if this variable was related to moral decision-making.

A mediation analysis was conducted using three regression analyses to determine the presence of a mediating relationship as depicted in Figure 4. These included the following: (i) ratings to moral dilemmas were regressed on MHI history; (ii) HR was regressed on MHI history; and (iii) ratings to moral dilemmas were regressed on both MHI status and HR measures.

Partial eta-square effect sizes were reported. Owing to the exploratory nature of this study, adjustments were not made to correct for Type 1 error. All the major analyses included sex as a covariate and this was not found to impact performance.

Results

Demographic data: History of MHI

Of the 24 students who reported a MHI, 14 (58.3%) experienced LOC. Ten students (41.6%) reported experiencing a LOC for less than 5 minutes, 3 (12.5%) reported a LOC greater than 5 minutes and less than 30 minutes, and 1 (4.1%) was unconscious for more than 30 minutes but less than a week. According to Kay et al.'s (1993) criteria of MTBI of LOC $\leq$ 30 minutes duration, the entire sample excepting one participant (Case 147) would be classified as having a MHI. Note, analyses were conducted for each outcome including, and excluding, Case 147 and the resulting outcomes were the same. As a result, the data for this subject were retained.

Eight (33.3%) of the 24 students who reported a experiencing a MHI, also indicated having had a prior head injury (i.e., reported two injuries). The characteristics of these injuries are illustrated in Table 3.

Table 3

Injury Characteristics and Etiology of Mild Head Injuries

	Most current MHI		Previous MHI	
	n	%	*n*	%
Number of students	24	100.0	8	33.3
Loss of consiousness	14	58.3	8	100.0
Less than 5 minutes	10	41.6	6	75.0
More than 5 minutes but	3	12.5	2	25.0

less than 30 minutes				
More than 30 minutes but less than a week	1	4.1	0	0.0
Concussion	15	62.5	8	100.0
Received medical treatment	11	45.8	4	50.0
Stitches	3	12.5	0	0.0
Overnight stay at medical facility	5	20.8	1	12.05
Causes of injuries				
Sporting activities	12	25.0	7	87.50
Falling	7	14.6	1	2.10
Motor vehicles accidents	3	6.3	0	0.00
Other	2	4.2	0	0.00
Mean age at injury (*SD*)	14.78	(4.12)	11.63	(4.30)
Years since injury (*SD*)	5.87	(4.20)	10.25	(5.54)

Comparability of matched samples

The MHI and non-injured control groups were compared in order to ascertain whether they had been matched effectively. Chi-square analysis revealed that the two groups did not differ in terms of gender (χ^2 ($df = 1, N = 48$) = .784, $p = .376$), education level (χ^2 ($df = 3, N = 48$) = 1.34, $p = .718$), and handedness (χ^2 ($df = 2, N = 48$) = 2.54, $p = .280$). Likewise, the groups were comparable in terms of their age, F (1, 46) = 1.87, $p = .178$.

In general, students with a history of MHI and non-injured controls responded similarly on their use of caffeine, F (1, 25) = 0.07, $p = .787$ ($M_{caffeine}$ = 1.25, SD = .96 vs $M_{caffeine}$ = 1.33, *SD* = .61 per cup), alcohol, F (1, 19.85) = 0.38, p = .540 ($M_{alcohol}$ = 11.69, *SD* = 6.72 vs $M_{alcohol}$ = 9.46, *SD* = 11.01), and relaxation techniques, F (1, 15) = 1.66, p = .216 ($M_{relaxation}$ = 2.00, *SD* = 2.64 vs $M_{relaxation}$ = .75, *SD* = .70 per week). However, students with a history of MHI (M = 8, *SD* = 5.59) reported consuming more cigarettes on a daily basis than non-injured students, (M = 2, *SD* = 3.25) F (1, 10 = 5.71, p = .038). As well, they reported engaging in more exercise activities on a weekly basis than non-injured students, F (1, 34) = 5.73, p = .02, ($M_{exercise}$ = 4.63, *SD* = 1.46 vs $M_{exercise}$ = 3.53, *SD* = 1.28).

Other pre-morbid health indicators such as recreational drugs, sensitivity to perfumes, hospitalization for neurological complications and surgeries did not differ as a function of MHI history (see Appendix B: Table 4). Likewise, the groups were comparable in terms of their history of other neural traumas. However, students with a history of self-reported MHI reported being hospitalized for fractures, χ^2 (df = 1, N = 48) = 7.11, p = .001, 41.7% vs 8.3% and illness χ^2 (df = 1, N = 48) = 4.06, p = .04, 50% vs 20.8%, more frequently than non-injured students. Notably, reports of arousal across different indicators such as current alertness, stress, mood, activity level, typical sleep, and sleep quality did not vary as function of history of MHI (see Appendix B: Table 5).

Regarding self-reported problems for which individuals receive professional diagnosis, both groups reported a similar history of psychiatric and neurological complications. Additionally, participants' intake of psychoactive drugs for these conditions did not differ by history of MHI. Further, both groups reported similar histories of educational assistance (e.g., occupational therapist, learning resource teacher and educational assistant, physical therapist and tutor) (see Appendix B: Table 4).

Several psychosocial measures such as living conditions (e.g., living with roommates, parents/guardians, partner, on his/her own) were not differentially reported as a function of MHI history (see Appendix B: Table 4). As well, both MHI and No MHI students self-scored similarly on the number of university credits currently undertaken, and their enjoyment of academics and life's situation (see Appendix B: Table 6).

Overall, the two groups were comparable. However, the variables of hospitalization for fractures and exercise frequency and cigarette smoking history were used as covariates in the analysis of baseline physiological arousal and were found to be non-significant (all p's < .05).

Time of day for testing.

Participants were tested during the winter semester at three time periods throughout the day: morning, afternoon and evening. Chi-square analysis demonstrated that the students were equally represented in these testing sessions across the orders of dilemmas for those with (χ^2 (df = 6, N = 48) = 6.04, p = .109) and without χ^2 (df = 6, N = 48) = 6.54, p = .419) MHI (refer to Tables 7-9).

A one-way between-subjects ANOVA (time of testing: morning, afternoon, evening) on baseline physiological arousal (HR frequency) was conducted to determine if the time of day on which the participants were tested impacted baseline physiological arousal. Results yielded a non-significant effect of time of day tested, F (2, 44) = .567, p = .571 (see Table 9).

Hypotheses

Hypothesis 1: *It was expected that participants who report a history of MHI would be more likely to demonstrate reduced levels of arousal on physiological and self-report measures during baseline and decision making performance compared to non-MHI participants.*

Baseline physiological arousal.

To test this hypothesis, a one-way between subjects ANOVA on baseline physiological arousal (HR frequency) was conducted. Consistent with our expectations, a significant Group effect, F (1, 45) = 5.42, p = .020 η_p^2 = .10, was found, such that participants who reported a history of MHI had lowered HR activity (frequency) at baseline (M = 72.25, SD = 11.11) than participants who reported no history of MHI (M = 78.65, SD = 7.23). [3] EDA levels produced a similar pattern, but were not significant (MHI - M = 0.55, SD = 1.42; no MHI - M = 1.13, SD = 1.29).

Physiological arousal during dilemma manipulation across time.

To continue testing hypothesis 1, we analyzed the HR activity (frequency) recorded prior to (anticipatory) reading each scenario, during the presentation of the scenario, during the response ratings and after responding (reactions) to each type of dilemma using four separate 2 (Group) x 6 (dilemmas) mixed ANOVA design with repeated measures on the last factor. Group means and standard deviations for these dependent variables are presented in Tables 10 - 13.

3 Note, analysis was conducted for only the physiological measure of HR frequency as there were no collection of baseline data for the Verbal Self-report and Perceived Arousal.

Table 10

Group Means and Standard Deviations for Anticipatory HR Activity to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	75.43	9.98	78.00	7.68
Deliberate non-moral	73.56	10.18	78.48	7.91
Unintentional non-physical harm	74.14	9.86	78.43	6.24
Deliberate non-physical	73.45	9.32	77.96	5.80
Unintentional physical harm	74.25	8.43	79.42	5.97
Deliberate physical harm	73.27	10.19	77.93	6.38

Anticipatory HR. While not significant, consistent with our hypothesis, there was a trend for participants with a history of MHI to show lowered anticipatory HR responses than participants without a history of MHI, F (1, 45) = 3.58, p = .065, η_p^2 = .07. However, there was no significant main effect of Type of dilemma, F^{GG} (5, 225) = 1.29, p = 0.27[4], η_p^2 = .02, nor was there an interaction between Group and Type of dilemma, F^{GG} (5, 230) = 1.07, p = 0.02, η_p^2 = .02.

4 Note, for all repeated measures ANOVA designs, Greenhouse-Geisser correction for the violation of sphericity was employed.

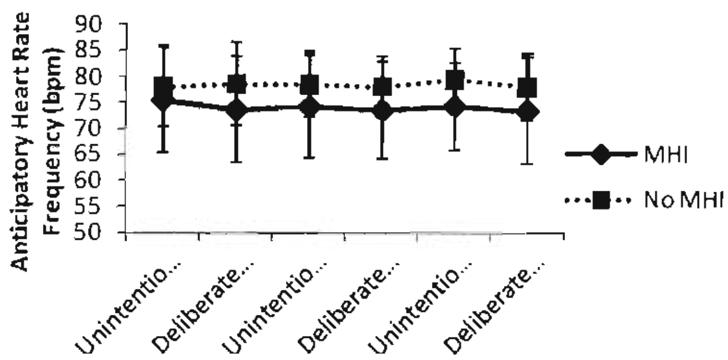


Figure 5. Anticipatory Heart Rate Activity (frequency) During Response to Dilemmas by MHI History.

Table 11

Group Means and Standard Deviations for Onset HR Activity to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	75.50	9.41	77.60	12.13
Deliberate non-moral	75.46	9.96	79.42	7.21
Unintentional non-physical harm	74.17	15.01	79.55	6.29
Deliberate non-physical harm	75.62	9.90	79.84	6.75
Unintentional physical harm	76.19	8.90	80.57	5.96
Deliberate physical harm	75.59	9.47	79.87	5.54

HR activity during the consideration of dilemmas. Similar to the anticipatory findings, again while not significant, there was a trend for participants with a history of self-reported MHI to demonstrate lowered HR activity while considering the dilemmas than students who reported no history of MHI, F (1, 45) = 3.00, p = .090, η_p^2 =.06. Once again, there was no significant main effect of Type of dilemma, F^{GG} (5, 225) = 0.91, p = 0.43, η_p^2 = .02, nor was there an interaction between Group and Type of dilemma, F^{GG} (5, 225) = 0.61, p = 0.61 η_p^2 = .01

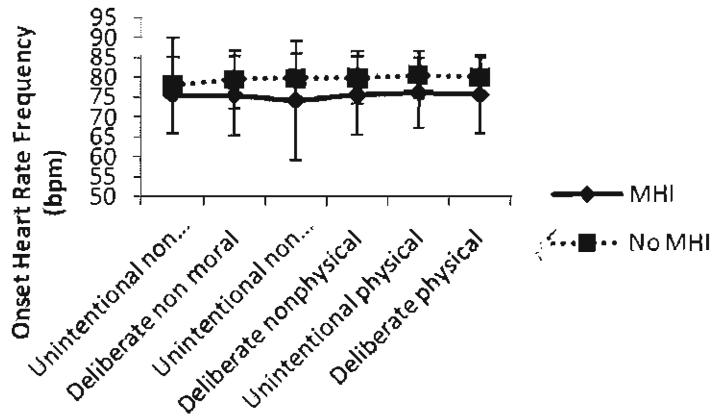


Figure 6. Onset Heart Rate Activity (frequency) During Response to Dilemmas by MHI History.

Table 12

Group Means and Standard Deviations for Response HR Activity to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	83.86	10.80	86.31	10.88
Deliberate non-moral	85.85	13.15	86.70	13.15
Unintentional non-physical harm	85.19	13.18	90.89	12.76
Deliberate non-physical harm	83.04	12.73	90.27	11.42
Unintentional physical harm	84.66	10.91	83.2	88.73
Deliberate physical harm	82.11	11.35	88.78	11.48

HR activity during response to dilemmas. Inconsistent with our expectations, there was no significant between the groups as a function of MHI status, $F\ (1, 45) = 1.871, p = .177, \eta_p^2 = .04$. In like manner, there was no effect of Type of dilemma, $F^{GG}\ (5, 2250) = 1.52, p = .199, \eta_p^2 = .03$. However, there was an interaction between Group and Type of dilemma, $F^{GG}\ (5, 225) = 2.33, p = .05, \eta_p^2 = .04$. Follow-up analysis repeated measures ANOVA's to compare HR activity across the Type of dilemmas for non-injured controls was significant, $F\ (5, 110) = 2.97, p =.01, \eta_p^2 = .11$, but was non-significant for participants with a history of MHI, $F\ (5, 115) = 0.81, p = .50, \eta_p^2 = .03$.

Pairwise comparisons indicated that participants without prior history of MHI had significantly lowered HR activity when making their responses to the unintentional physical harm dilemmas when compared to unintentional non-physical harm ($p = .05$) and deliberate non-physical violations ($p = .02$).

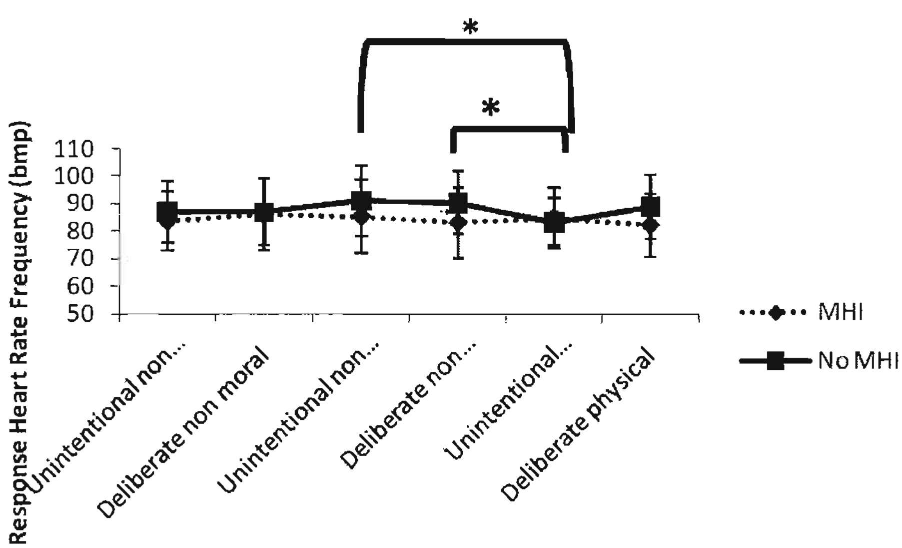


Figure 7. Response Heart Rate activity (frequency) During Response to Dilemmas by MHI History. Note that HR differentiation between dilemmas occurred for the No MHI group only.

Table 13

Group Means and Standard Deviations for Reaction HR Activity to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	72.29	9.52	77.86	7.74
Deliberate non-moral	74.06	11.12	78.71	7.37
Unintentional non-physical harm	72.32	9.95	73.42	7.57
Deliberate non-physical harm	73.61	10.25	76.54	6.99
Unintentional physical harm	74.06	9.85	77.01	6.56
Deliberate physical harm	72.32	10.41	76.72	8.00

Reactionary HR activity. University students with a history of self-reported MHI did not demonstrate lowered HR during their reactions to the responses made to the dilemmas compared to students without MHI, F (1, 45) = 2.59, p = .11. However, a significant effect of Type of dilemma, F^{GG} (5, 225) = 2.55, p = .043 was found. Pairwise comparisons indicated that HR activity for Unintentional non-physical harm violations were lower compare to Deliberate non-moral, Deliberate non-physical and Unintentional physical harm violations. However, the interaction between MHI Group and Type of dilemma was not significant, F^{GG} (5, 225) = 1.17, p = .322.

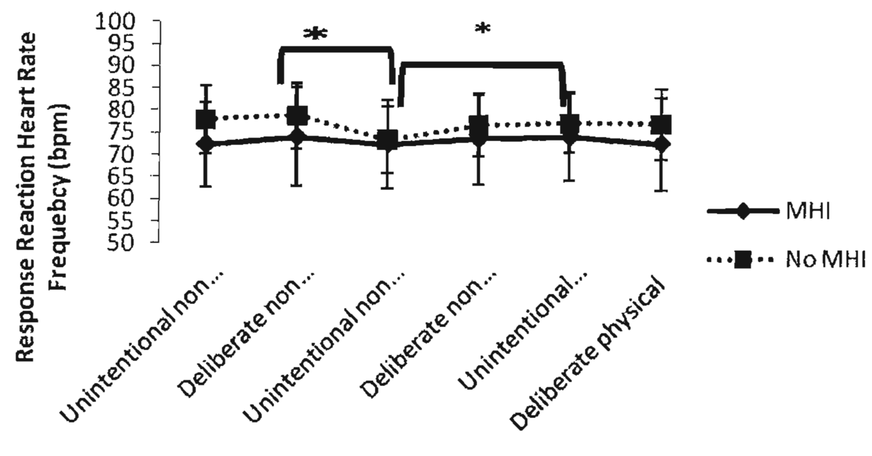


Figure 8. Heart Rate Activity During Response Reaction (frequency) to Dilemmas by MHI History. Note that response to dilemmas did not differ with respect to group.

Self-report of arousal during dilemma manipulation.

To further test hypothesis 1, we submitted the self-reported arousal ratings to the six categories of dilemmas to a 2 (Group) x 6 (Type of dilemmas) mixed ANOVA design with repeated measures on the last factor. The group means and standard deviations for self-reported arousal ratings to the six types of dilemmas are shown in Table 14.

Table 14

Group Means and Standard Deviations for Self-reported Arousal Ratings to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	2.38	1.31	3.36	1.83
Deliberate non-moral	2.60	1.15	3.13	1.55
Unintentional non-physical harm	3.17	1.82	3.36	1.52
Deliberate non-physical harm	3.17	1.87	3.54	1.68
Unintentional physical harm	3.34	2.05	3.86	2.03
Deliberate physical harm	4.34	2.44	4.45	2.28

With respect to self-report of arousal, the Group effect was non-significant, $F\ (1, 43) = .858$, $p = .360$, $\eta_p^2 = .02$; however, a significant effect of Type of dilemma, $F^{GG}\ (5, 215) = 16.59$, $p = .0001$, $\eta_p^2 = .34$ was found, such that higher ratings of arousal state were assigned to dilemmas leading to serious bodily harm (e.g., pushing an injured man overboard) compared to other dilemmas: Unintentional non-moral, Deliberate non-moral, Unintentional non-physical, Deliberate non-physical. There was no Group by Type of dilemma interaction, $F^{GG}\ (5, 215) = 1.23$, $p = .360$, $\eta_p^2 = .02$.

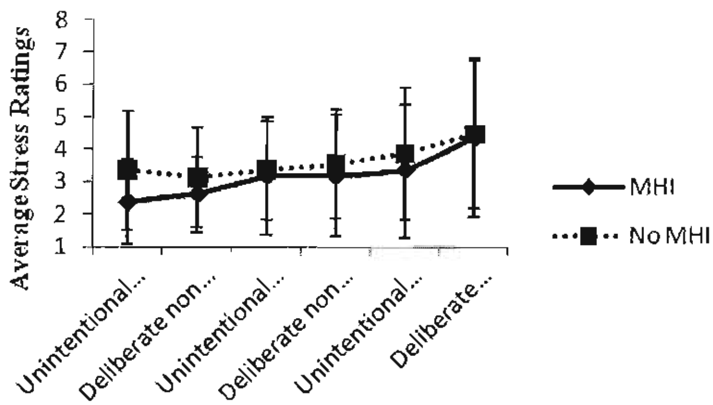


Figure 9. Average Stress Ratings to Dilemmas by MHI history.

Taken together, these results provide some evidence that participants with a history of self-reported MHI produce lowered HR activity relative to their No MHI cohort both at baseline and, variably, during certain types of emotionally distressing, or arousing, situations.

Self-report of life stressors. While not significant, there was a statistical trend for students with a history of MHI (M = 138.96, SD = 62.91) to endorse a significantly higher number of life stressors such as death of a relative, personal illness and financial challenges, than students who reported no history of MHI, (M = 98.08, SD = 82.35), t (45) = -1.90, p = .063, despite experiencing lowered arousal state as indicated by baseline physiological recordings (HR activity).

Hypothesis 2: *It was expected that participants who report a history of MHI would differ from non-MHI participants in their decisions and response time on the moral dilemmas: More specifically: it was hypothesized that participants with a history of MHI would rate themselves as more likely to report that they would commit moral violations independent of the intentionality (deliberate or unintentional) and outcome (physical harm, non-physical harm, no harm) of the dilemma, and would do so more quickly, than their non-MHI counterparts.*

Ratings to moral dilemmas.

To test hypothesis 2, we analyzed the ratings to the six categories of dilemmas using a 2 (Group) x 2 (Intentionality) x 3 (Moral outcomes) mixed ANOVA design with repeated measures on the last two factors. The group means and standard deviations for the ratings to the six types of dilemmas are presented in Table 15.

Table 15

Group Means and Standard Deviations for Ratings to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	1.94	0.67	1.99	0.68
Direct non-moral	1.67	0.72	1.22	0.75
Unintentional non-physical harm	1.17	0.46	1.33	0.71
Direct non-physical harm	2.04	0.51	2.19	0.78
Unintentional physical harm	1.68	0.58	1.43	0.73
Direct physical harm	1.39	0.98	0.93	0.62

There was no Group effect for how participants rated their likelihood of engaging in the actions described in the dilemma, $F\ (1, 46) = .898, p = .35, \eta_p^2 = .01$. Likewise, the main effect of Intentionality, $F\ (1, 46) = .449, p = .51, \eta_p^2 = .01$, was not significant. However, a significant main effect of moral outcomes, $F\ (2, 92) = 38.58, p = .001, \eta_p^2 = .45$, emerged indicating that violations leading to non-moral outcomes were more likely to be endorsed over violations involving non-physical outcomes, which in turn, were more likely to be endorsed over those leading to serious bodily harm (p < .001 in all comparisons). A significant Group by Intentionality by Moral outcome interaction was also found, $F\,(2, 92) = 4.96, p = .001, \eta_p^2 = .09$ (see Figure 10).

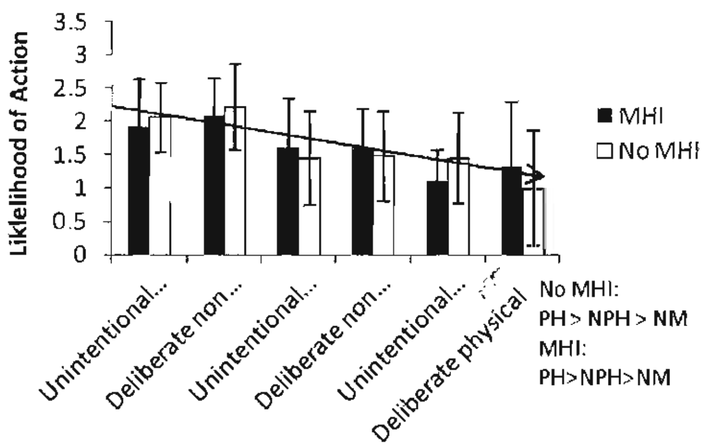


Figure 10. Liklihood of Engaging in transgression by MHI History. Note: follow-up analyses of the three-way interaction showed that both groups participants were more willing to report that they would commit violations that resulted in non-moral outcomes over those involving non-physical outcomes, which in turn, were more likely to be committed over physical ones. (see figure 11 for further follow-up analyses)

Follow-up repeated measures ANOVA's showed a non-significant Intentionality by Moral outcome interaction for MHI participants, $F\,(2, 46) = .461, p = .618, \eta_p^2 = .02$, but a significant main effect of Moral outcomes, $F\,(2, 23) = 13.52, p = .001, \eta_p^2 = .37$. In contrast, a significant Intentionality by Moral outcome interaction was found for participants who reported no history of MHI, $F\,(2, 46) = 8.02, p = .01, \eta_p^2 = .25$. Follow-up analysis repeated measures ANOVA's to compare each level of intentionality for non-injured controls were significant for both unintentional, $F\,(2, 46) = 14.09, p = .001, \eta_p^2 = .38$ and deliberate violations, $F\,(2, 46) = 28.38, p = .001, \eta_p^2 = .55$. Pairwise comparisons indicated that non-injured controls were more willing to endorse unintentional non-moral violations over those leading to unintentional non-physical harm (e.g., confidential information valuable to investors was left unattended and a friend walks in your office sees them), $p = .01$ and unintentional physical harm outcomes (e.g., turning a runaway trolley away from five persons but towards one person by pressing a switch), $p = .001$, respectively. However, no differences were noted in the ratings to unintentional non-physical and unintentional physical harm violations, $p = .413$.

Regarding the Deliberate dilemmas, post-hoc comparisons indicated that non-injured participants were more willing to carry out non-moral violations over those involving non-physical harm outcomes (e.g., reporting certain personal expenses as business expenses in order to lower one's taxes), $p = .01$, which in turn were committed more willingly over those violations leading to serious bodily harm, $p = .001$ (see Figure 11).

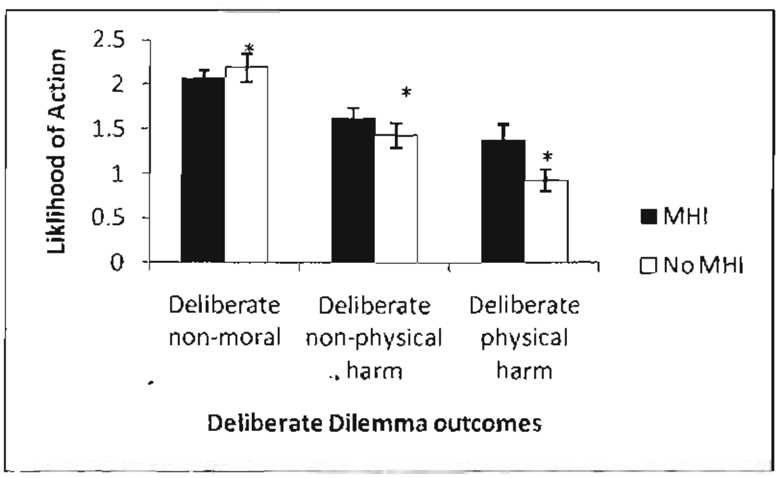


Figure 11. Average Endorsement Ratings to Deliberate (deliberate) Dilemmas for both no MHI and MHI Students. Note; deliberate non-moral violations were more likely to be committed over deliberate non-physical, which in turn was more likely to be committed over deliberate physical only for non-injured students (*p <.05)

Pairwise comparisons showed that for participants with a history of MHI, violations leading to non-moral outcomes (e.g., choosing to use walnuts over macadamia nuts in a recipe) were more likely to be endorsed over non-physical ones (e.g. stealing), $p = .05$, and those resulting in physical harm, $p = .001$. Non-physical harm violations, in turn, were more likely to be endorsed over transgressions resulting in serious bodily harm (e.g., pushing a drowning man overboard), $p = .02$.

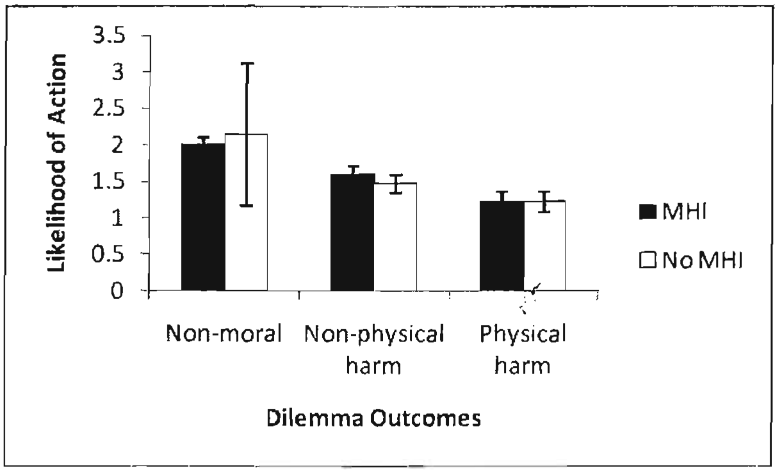


Figure 12. Average Endorsement Ratings to the Type of Dilemma outcome Scenarios for MHI and no MHI students. Note; non-moral violations were more likey to be committed over non-physical harm outcomes,which were more likely to be committed over physical harm outcomes for both groups of participants (*$p<.05$).

When the ratings were examined as a function of comparing endorsement of the action or not (i.e., ratings of ≥ 1 versus 0), the pattern of results was similar.

When the ratings were examined as a function of which type of moral action was more likely to be endorsed (nonphysical or physical harm) as a function of Intentionality, more MHI participants endorsed deliberate actions associated with physical harm outcomes (χ^2 ($df = 1$, $N = 23$) $= 7.74$, $p = .007$) than the non-injured participants (see Figure 13).

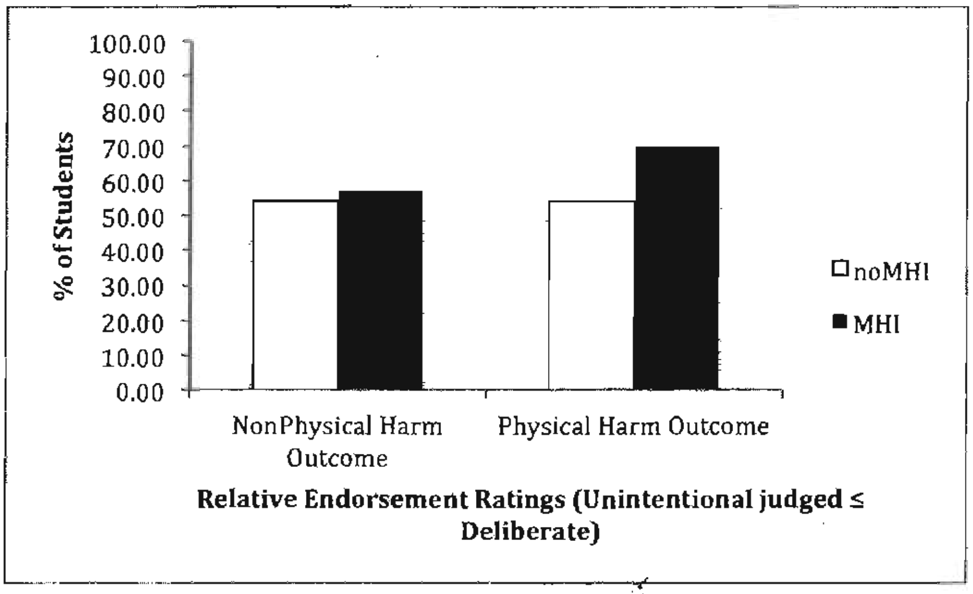


Figure 13. Percentage of Participants who Endorsed Engaging in Deliberate over Unintentional actions as a Function of Physical Harm Outcomes for both MHI and No MHI students

Thus, the above results provide support for our hypothesis that participants with a history of MHI would not be sensitive to the intentionality of the transgressions committed compared to non-injured controls. However, they were more sensitive to outcomes of the transgressions. Of note, participants with a history of MHI were more inclined, albeit subtle, to authorize deliberate violations that led to physical harm outcomes.

Response times to moral dilemmas.

To further test hypothesis 2, the response times to the six categories of dilemmas were analyzed using a 2 (Group) x 2 (Intentionality) x 3 (Dilemma outcomes) mixed ANOVA design with repeated measures on the last factor. The group means and standard deviations for the ratings to the six types of dilemmas are presented in Table 16.

Table 16

Group Means and Standard Deviations for Response Times to Types of Dilemmas

	MHI		No MHI	
Variable	M	SD	M	SD
Unintentional non-moral	2.92	1.02	3.80	1.74
Deliberate non-moral	2.31	0.57	2.39	0.93
Unintentional non-physical barm	3.03	1.15	2.79	1.22
Deliberate non-physical harm	2.26	0.97	2.24	0.84
Unintentional physical harm	2.80	1.14	2.80	1.14
Deliberate physical harm	2.73	1.38	2.38	0.93

Results from this analysis produced no Group effect, $F(1, 46) = .282, p = .60, \eta_p^2 = .001$, for the time participants took to respond to the dilemmas. However, there was an overall effect of Dilemma outcomes, $F(2, 92) = 3.34, p = .04, \eta_p^2 = .06$. Pairwise comparisons indicated only a trend toward faster response times for violations associated with non-physical outcomes compared to non-moral outcomes. There was an effect of Intentionality, $F(1, 46) = 33.30, p = .001, \eta_p^2 = .42$, indicating that faster decisions responses were given to the violations associated with deliberate actions than those that were unintentional. A significant Group by Intentionality by Dilemma outcomes interaction was also found, $F(2, 92) = 4.24, p < .017, \eta_p^2 = .08$ (see Figure 14)

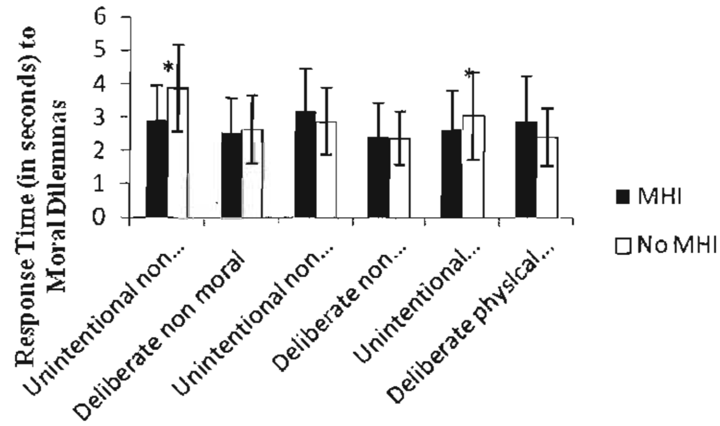


Figure 14. Response Time (in seconds) to Moral Dilemmas by MHI History. Note, both groups of participants took a long time to respond to unintentional non-moral dilemmas relative to rest of dilemmas. As well, both groups of participants responded more quickly to unintentional physical harm dilemmas compared to the rest of dilemmas, $*p < .05$

Follow-up repeated measures ANOVA's showed a significant Intentionality by Moral outcome interaction for both MHI participants, $F\ (2, 46) = 9.03, p = .001, \eta_p^2 = .28$ and non-injured controls, $F\ (2, 46) = 7.67, p = .001, \eta_p^2 = .25$. No MHI participants produced a significant effect for unintentional violations, $F\ (2, 46) = 8.71, p = .001, \eta_p^2 = .27$, but not deliberate violations, $F\ (2, 46) = .46, p = .63, \eta_p^2 = .02$; whereas participants with a history of MHI produced a significant effect for both unintentional violations, $F\ (2, 46) = 4.51, p < .016$, $\eta_p^2 = .16$ and deliberate violations, $F\ (2, 46) = 3.03, p = .05, \eta_p^2 = .11$.

Pairwise comparisons indicated that participants who sustained a MHI made faster responses to unintentional violations leading to serious physical harm compared to those leading to non-physical harm outcomes, $p = .05$ and non-moral outcomes, $p = .034$. However, no differences emerged in the response times between unintentional non-moral violations and unintentional non-physical harm violations. Pairwise comparisons also showed no differences in the response time among deliberate violations.

Non-injured participants made faster responses to unintentional violations that led to serious bodily harm than to those resulting in non-moral outcomes, $p = .004$. Faster responses were given to unintentional transgressions that involved non-physical harm outcomes than to those leading to non-moral outcomes, $p = .001$. However, there were no differences in the response times between unintentional non-physical and unintentional physical harm violations.

In summary, the above results provide some support, albeit subtle, for our hypothesis that participants with a history of MHI would respond more quickly to the violations relative to non-injured controls. Indeed, they only responded faster to violations that were committed unintentionally and led to physical harm.

Self-report of justification for moral decisions

Participants' explanations were first analyzed by computing the proportions of responses to each justication sub-category . To detect any group differences in the participants explanations, chi-square tests were performed.

Participants generally gave "insufficient justification" when providing explanations for their moral decisions. Overall, only 8% provided a "discounting" explanation, while 92% provided some acknowledgement of a utilitarian or moral conflict. No students provided a "sufficient" justification that acknowledged a discrepancy between the intentionality of the scenarios presented. Participants without a MHI were more likely to acknowledge a moral dilemma in their justification (40%) than MHI students (28%), whereas MHI participants were more likely to acknowledge a strictly utilitarian explanation for their choices (14%) as compared to their no MHI cohort (8%), (χ^2 ($df = 4$, $N = 23$) = 23.16, $p = .001$) (see Table 17).

Table 17

Descriptive Statistics (percentages) Justification Ratings as a function of MHI Status

Justification	no *MHI*	*MHI*
Sufficient Justification	0.0	0.0
Insufficient/Partial Justification	95.0	86.1
Utilitarian+Deontological	47.5	41.7
Deontological only	40.0	27.8
Utilitarian only	7.5	13.9
'Gut' feeling	0.0	2.8
Discountable Justification	5.0	13.9

Executive Function performance

Social Problem Solving Inventory-Revised (SPSI-R; D'Zurilla et al., 2002). Participants' ratings to each subscale of the SPSI-R measure were analyzed using separate one-way ANOVAs. Results showed that both groups of participants viewed themselves equally in terms of their overall social problem solving capacities, $F\ (1, 46) = .589, p = .442, \eta_p^2 = .01$. Further, results also showed that the groups were comparable in terms of how they viewed themselves with respect to the other problem solving dimensions (e.g., positive problem orientation, rational problem solving, negative problem orientation, impulsivity/carelessness style and avoidance style) of the social problem solving model (see Appendix B: Table 43). Thus, MHI participants' social reasoning abilities were similar to non-injured controls thereby confirming no pronounced differences in the groups' abilities to solve the social dilemmas.

Hypothesis 3: *It was expected that a history of MHI would be reflected by reduced arousal levels and it is this lowered physiological feedback that influences one's decision making. Therefore, MHI status would be indirectly related to decision making as a function of physiological arousal.*

Mediation of moral ratings by HR activity

The hypothesized mediating role of arousal (HR activity during the onset of dilemma) between MHI history and moral decision making could not be fully examined as there was no relationship between history of MHI and deliberate physical harm ratings nor between ratings and HR activity. The descriptive statistics and correlation for these variables are presented in Table 18 and Table 20 respectively. Interestingly, there was a significant negative relationship between MHI status and the subject's heart rate activity for deliberate physical harm endorsement, indicating that participants with a history of self-report MHI demonstrated lowered HR activity.

Table 18

Descriptive Statistics for Deliberate Physical Harm Ratings, HR activity (Onset), and MHI Status

Variable	*n*	*M*	*SD*
Deliberate physical harm	48	1.15	0.83
HR activity	48	77.30	8.29
MHI history	48	0.51	0.50

Table 19

Correlations Among Deliberate Physical Harm Ratings, HR activity, and MHI Status

Variable	1	2	3
Deliberate physical harm	_	-.17	.27
HR activity		_	-.34*
MHI history			_

*$p < .05$

As well, the mediation model involving unintentional physical harm ratings could not be examined as there were no relationships among history of MHI, unintentional physical harm ratings and HR activity. The descriptive statistics and correlation for the variables are presented in Table 20 and Table 21. Again, there was a significant relationship between MHI status and the subject's heart rate activity. All other variables were reviewed and demonstrated a similar pattern.

Table 20

Descriptive Statistics for Unintentional Physical Harm Ratings, HR activity (Onset), and MHI Status

Variable	*n*	*M*	*SD*
Unintentional phys. harm	48	1.26	0.60
HR activity	48	77.30	8.29
MHI history	48	0.51	0.50

Table 21

Correlations Among Unintentional Physical Harm Ratings, HR activity, and MHI Status

Variable	1	2	3
Unintentional phys. harm	_	.04	.28*
HR activity		_	-.34*
MHI history			_

$p^* \leq .05$

Hypothesis 4: *It was expected that MHI participants would be more likely to perform poorly on test of executive functioning that tap cognitive flexibility, working memory and attention when compared to non-MHI participants, and may be reflected in differences in moral decision making.*

To assess the validity of this hypothesis, separate one-way ANOVAs were used to analyze the response times, accuracy, self-corrected and uncorrected errors for the relevant domain of the cognitive measures.

Cognitive flexibility. Inconsistent with expectations that participants with a history of self-report MHI would performed poorly on tests of cognitive flexibility, results showed that participants with a history of self-reported MHI were more accurate ($M_{accuracy} = 3.83$, $SD = .86$ vs $M_{accuracy} = 3.33$, $SD = .63$), $F(1, 46) = 5.17$, $p = .028$, $\eta_p^2 = .10$, and faster ($M_{speed} = 4.12$, $SD = 1.36$ vs $M_{speed} = 4.94$, $SD = .87$), $F(1, 46) = 6.17$, $p = .017$, $\eta_p^2 = .11$, than non-injured participants in their responses on the 'number task' which involved repeating a list of numbers in sequential order (see Figures 15 and 16, and Appendix B: Table 44).

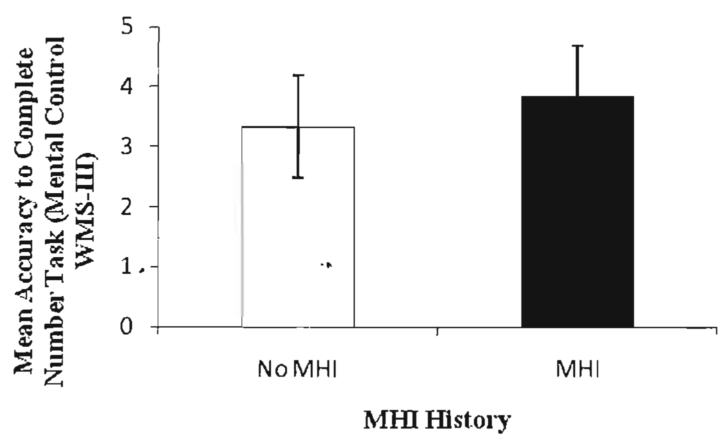


Figure 15. Accuracy score for MC-number task (WAIS-III, 1997) as a function of MHI history.

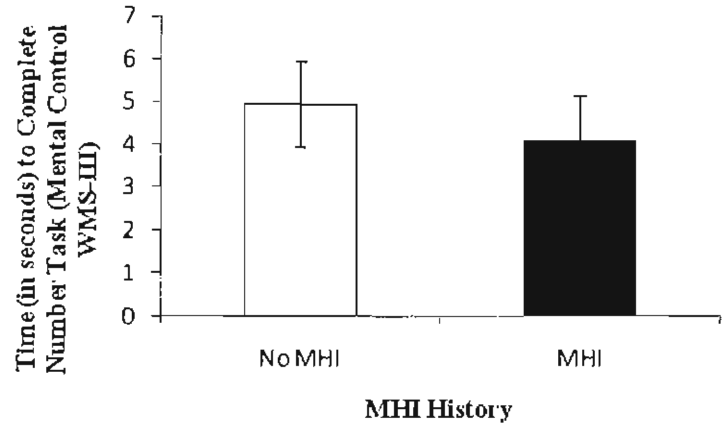


Figure 16. Response Time for MC-number Task as a Function of MHI History

Similarly, participants who report a history of MHI were more accurate ($M_{accuracy}$ = 3.17, *SD* = .56 vs $M_{accuracy}$ = 2.79, *SD* = .50), F (1, 46) = 5.84, p = .020, η_p^2 = .11, and faster (M_{speed} = 2.16, *SD* = .56 vs M_{speed} = 2.74, *SD* = .79), F (1, 46) = 8.47, p = .006, η_p^2 = .15, than non-injured participants on the 'days task' which involved repeating the days of the week in sequential order (see Figures 17 and 18).

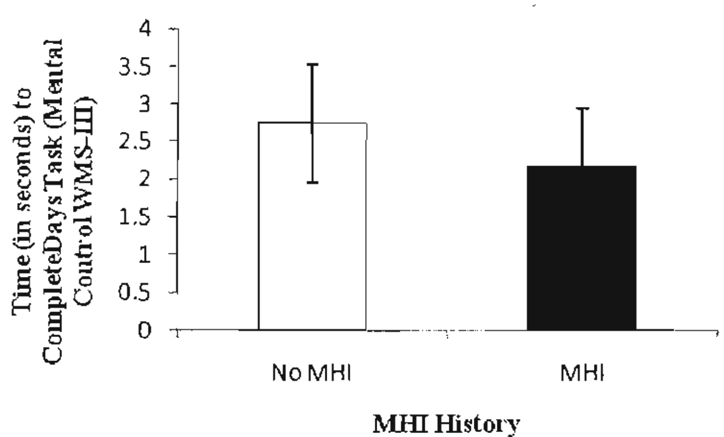


Figure 17. Response Time to Complete MC-days Task as a Function of MHI History.

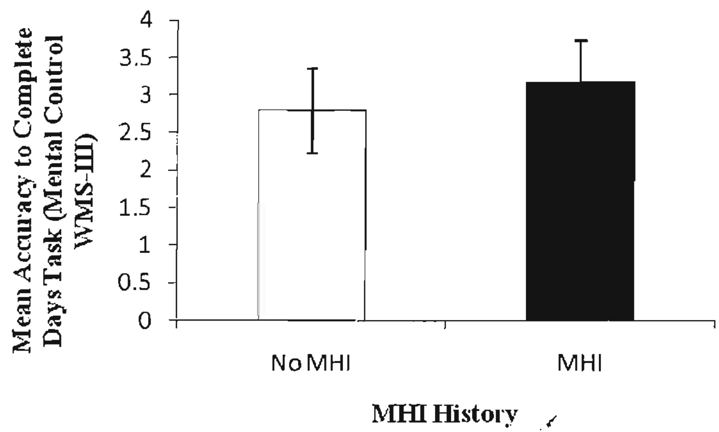


Figure 18. Accuracy Score to Complete MC-days Task as a Function of MHI History.

Working memory. Inconsistent with our expectations, participants with a history of MHI did not differ from non-injured controls on the 'Trail Making number task' (DKEFS, 2002), (see Appendix B: Table 45) .

Abstract reasoning. Contrary to expectations, there were no significant differences in the groups' abstract reasoning capacities, $F\,(1, 43) = .460, p> = .05, \eta_p^2 = .09$, and the time taken, $F\,(1, 26) = .635, p > .05, \eta_p^2 = .02$, to respond to the Pictorial Analogies Test (CTONI, 1996) (see Appendix B: Table 46).

Attention. The Colour-Word Interference subtest (DKEFS, 2002) differentiated students with a history of MHI from non-injured controls. Students with a history of self-reported MHI performed faster ($M_{speed} = 2.16$, $SD = .56$ vs $M_{speed} = 2.74$, $SD = .79$), $F\,(1, 45) = 3.98, p = .052$, $\eta_p^2 = .08$, on the colour naming task (see Figure 19) (see Appendix B: Table 47); but no other differences were found.

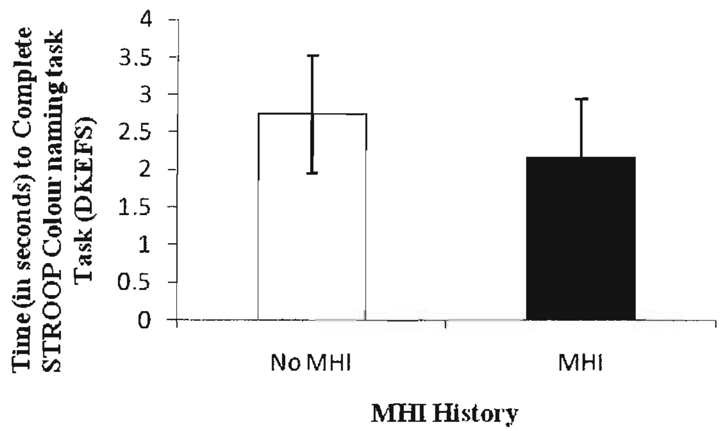


Figure 19. Response Time to Complete the Stroop Colour Naming Task as a Function of MHI History

Taken together, these findings did not provide evidence that participants with a history of MHI would perform more poorly on neurocognitive tests assessing cognitive flexiblity, working memory, abstract reasoning and attention.

To further test the hypothesis that executive functioning measures would be related to ratings, a multiple hierarchical regression analysis was conducted in which unintentional non-physical harm ratings was regressed on HR activity (onset) on step 1, followed by executive functioning measures on step 2 and MHI status on the third step.

It must be noted that prior to conducting the hierarchical multiple analysis regression analysis, several assumptions (e.g., independence of residuals, normality of residuals, homoscedasticity, linearity) were explored, but were not fully satisfied (e.g., linearity, homoscedasticity). Thus, the results must be interpreted with caution. The means and standard deviations of the variables included in this model are displayed in Table 22.

Predictors of moral decision making.

Table 22

Descriptive Statistics for Unintentional Non- Physical Harm Ratings, HR activity (Onset), Executive Functioning Measures and MHI Status

Variable	*n*	*M*	*SD*
Unintentional non phys. rat.	46	1.43	0.76
Unintentional nonmor HRact.	46	76.99	9.07
Deliberate non mor. HR act.	46	77.02	8.84
Uninten. Non phys. HR act.	46	77.22	8.89
Deliberate non phys HR act.	46	77.03	8.61
Uninten. phys. HR activity	46	77.82	8.00
Deliberate phys HR activity	46	77.10	7.80
MC- Number response time	46	4.55	1.20
MC- Number accuracy	46	3.57	0.77
MC- Days response time	46	2.43	0.75
MC-Days accuracy	46	2.98	0.57
Stroop-Color naming time	46	28.20	4.80
Stroop-Color naming acc.	46	0.13	0.40
MHI status	46	0.48	0.50

The correlations among the variables are displayed in Table 23. The results of the hierarchical multiple regression are presented in Table 24. Overall, 48% of the variability in unintentional non-physical harm ratings was accounted for by HR activity during the consideration of the scenarios, executive measures and MHI history, F (14, 31) = 2.04, p = .048. As depicted in Table 24, HR activity during the onset of the scenarios for the deliberate non-physical harm dilemmas significantly and independently predicted unintentional non-physical harm ratings, (p = .05), while the other variables together with this same variable accounted for 23% of the variability in unintentional non-physical harm ratings, for step 2, $F\Delta(6, 39) = 2.04$, p = .08. Executive functioning measures such as MC-Number accuracy did not significantly improve the prediction of unintentional non-physical harm ratings in block 2, $F\Delta$ (7, 32) = 1.44, p = .22. However, MHI history uniquely improved the model's prediction by 5.8% in step 3, $F\Delta$ (1, 31) = 3.44, p = .07.

It must be noted that the multiple hierarchical regression analyses for the ratings of the other three moral dilemma scenarios (deliberate non-physical harm, unintentional physical harm and deliberate physical) was regressed on HR activity (onset) on step 1, followed by executive functioning measures on step 2 and MHI status on the third step, and were not significant (see Appendix B: Tables 48-56). Therefore, our findings did not provide evidence that executive functioning would predict moral decision-making.

Table 23

Inter-correlations of Participants' Unintentional Non-Physical Harm Ratings with HR Activity (Onset), Executive Functioning Measures and MHI Status

							N = 46								
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unint. Non P ratings	_	-.01	-.10	-.08	-.17	-.02	-.03	-.21	.34***	-.03	-.16	.16	-.05	-.24*	.28*
Unint. Non mor. HR		_	.95***	.93***	.91**	.92**	.87***	.31***	-.30*	.37**	-.24**	.06	.25*	-.32	-.20
Deli. Non mor. HR			_	.93***	.94***	.90***	.89***	.29*	-.29*	.35***	-.17	.04	.24	-.28*-.	19
Unint. Non P HR				_	.93***	.91***	.88***	.25	-.23	.26	.20	.07	.24	-.31*	.20
Deli. Non P HR					_	.85***	.87***	.31**	-.30**	.34**	-.18	.04	.24*	-.23	-.20
Unint.P HR						_	.91***	.28	-.26	.34	-.26	.17	.25*	-.33	-.23**
Delib. Phys.HR							_	.28*	-.24*	.32*	-.23*	.20	.30*	-.28*	-.22*
MC-Number response time								_	-.84*	.24	-.20	.17	.30	.06	-.33*
MC-Number accuracy									_	.20	.22	.03	-.19	-.17	.31*
MC-Days response time										_	-.54***	.20	.15	-.04	-.44***
MC-Days accuracy											_	.01	-.11	.01	.34*

Table 23 Continued

Inter-correlations of Participants' Unintentional Non-Physical Harms Ratings with HR Activity, Executive Functioning Measures and MHI Status

Trails-Number accuracy	_	.14	-.08	-.25
Stroop-Color naming response time		_	-.10	-.26
Stroop-Color naming UC			_	-.31*
MHI status				_

*p <.05

**p < .01

***p < .001

Table 24

Hierarchical Multiple Regression Analyses Predicting Unintentional Non-Physical Harms Ratings from HR Activity, Executive Functioning Measures and MHI Status

Predictor	β	B	ΔR^2	$F\Delta$	*df*	*p*	sr^2
Step 1							
Unint.N Mor HR activity	0.94	0.80	0.23	2.04	6, 39	.08	0.06
Deli. N Mor HR activity	-0.47	-0.04					0.01
Unint. N P HR activity	-0.12	-0.01					0.00
Deli. N P HR activity	-1.02	-0.09					0.07
Unint. P HR activity	-0.05	-0.00					0.00
Deli. Phy HR activity	0.68	0.06					0.05
Step 2							
MC-Number time	0.20	0.12	0.18	1.44	7, 32	.00	0.00
MC-Number accuracy	0.52	0.51					0.06
MC-Days time	-0.20	-0.21					0.02
MC-Days accuracy	-0.28	-0.37					0.04
Trails Number error	0.08	0.25					0.00
Stroop-Color naming time	-0.07	-0.01					0.00
Stroop-Color naming UC	-0.11	-0.22					0.01
Step 3							
MHI status	0.32	0.49	0.05	3.44	1, 31	.25	0.01

Hypothesis 5*: It was expected that students with a history of MHI would report even more PCS, with greater frequency, with greater intensification and for longer periods of time than non-injured students.*

Endorsement of Post-concussive Symptoms

Separate independent t-tests indicated no significant differences in the groups' endorsement for the duration, t (37.07) = -0.66, p = .509, intensity, t (37.43) = -0.58, p = .559, and frequency, t (34.65) = -0.27, p = .781, of PCS symptoms. Likewise, there were no significant differences in the groups' overall experience of PCS complaints, t (35.11) = -0.52, p = .603 (see Figures 20-24) (refer to Appendix B: Table 57). Thus, these results did not provide support our hypothesis.

Mann-Whitney U tests were conducted on the differences in the endorsement of concentration challenges experienced by the participants. Results showed that the two groups did not differ significantly in the frequency, z = -0.04, p = .965, intensity, z = -0.06, p = .947, nor duration, z = -0.60, p = .548, of these symptoms. Likewise, separate Mann-Whitney U tests also showed no group differences in the endorsement of other types of PCS complaints (e.g., headache, irritability, fatigue, judgment, memory and anxiety (refer to Appendix B: Tables 58-60).

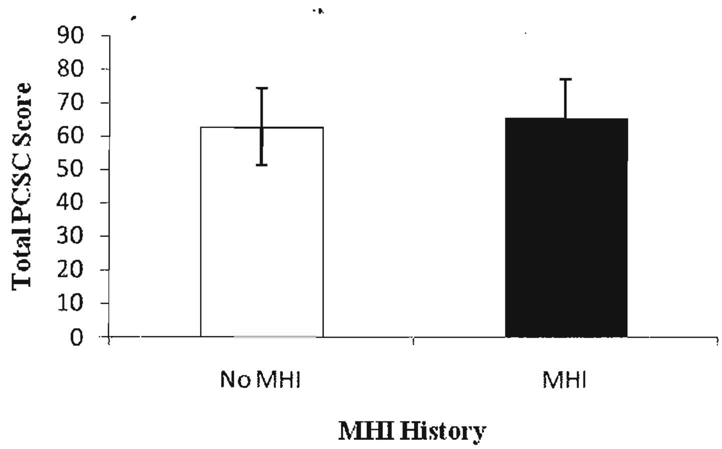


Figure 20. Total PCSC Score as a Function of MHI History

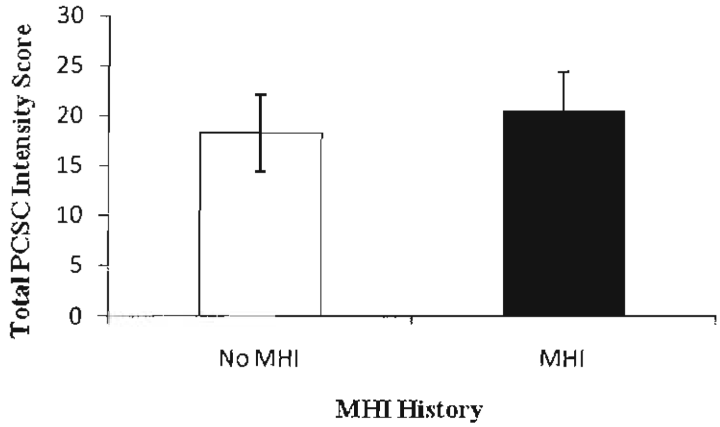


Figure 21. Total PCSC Intensity Score as a Function of MHI History

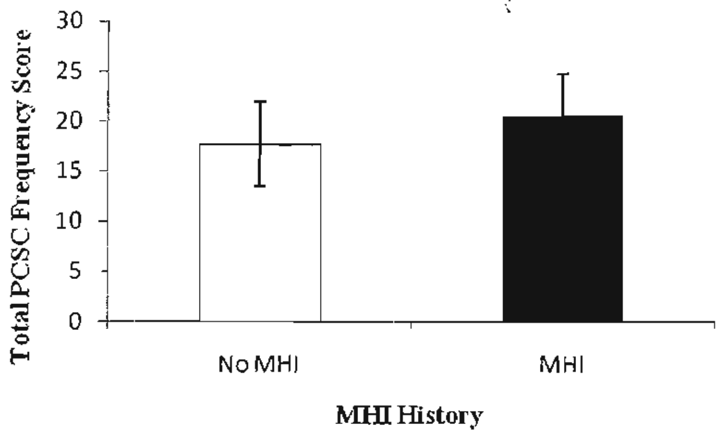


Figure 22. Total PCSC Frequency Score as a Function of MHI History

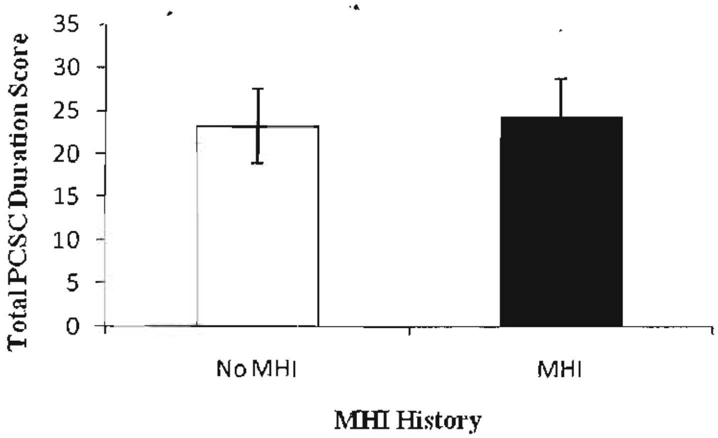


Figure 23. Total PCSC Frequency Score as a Function of MHI History

Summary of results

After applying Kay et al.'s (1993) criteria for a MHI, it was found that 33% of university students in the sample reported a MHI with females making up 54% of this number. The majority incurred their injury from sports-related activities and falls at the age of 15 years. In terms of injury characteristics, 33.3% of these students reported an additional head injury while more than half reported LOC, for which the majority experienced for less than 5 minutes. Interestingly, less than half of these students received medical attention.

Both groups were generally the same with respect to reports of overall PCS and the qualitative aspects for which these symptoms were experienced. Contrary to expectations, students with a history of self-reported MHI performed comparably, and even better, on tasks assessing cognitive flexibility, working memory and attention compared to students who did not report a MHI.

Consistent with expectations, university students with a history of self-reported MHI did not differentiate between the intentionality of the violations when compared to non-injured controls. However, they differentiated among violations leading to non-moral, physical harm and non-physical harm violations similar to non-injured students. Essentially, they were more likely to report that they would commit non-moral violations over transgressions resulting in non-physical harm outcomes, which in turn were more likely to be authorized over dilemmas that led to serious physical harm. Further, they were noted to report that they would be more willing to commit deliberate violations that led to physical harm outcomes, albeit subtly.

Regarding reaction times to the dilemmas, findings were inconsistent with our hypothesis, as there were no differences in the reaction times to the dilemmas, excepting those that were committed unintentionally and which led to physical harm outcomes.

University students with prior history of MHI demonstrated lowered physiological arousal (HR activity) responses at baseline, which tended to be evident across the study (prior to, i.e., anticipatory, and during the consideration of each type of dilemma).

Regarding the relative contributions of cognitive skills, physiological responding and MHI history as predictors of moral decision making, results showed that HR activity (onset) significantly predicted unintentional non-physical harm ratings, independent of cognitive skills and MHI history.

Discussion

The aim for the present study was to replicate and extend Chiappetta and Good's (2010) study by exploring the relationship between MHI and moral decision-making in university students. Additionally, individual differences in cognitive, physiological responsivity, social reasoning and PCS were examined as they related to MHI and the kinds of moral decisions made by university students.

The overall prevalence of self-reported MHI was 33% of the original sample. One-third of the MHI students reported having more than one head injury. This is comparable to the incidence rate for head injury in a similar population of university students found by others (e.g., Segalowitz & Lawson, 1995; Baker & Good, 2007) using the Kay et al.'s (1993) liberal definition of MHI. Notably, fewer than half of the sampled individuals indicated that they had received medical attention, while 12.5% of the students reported receiving stitches and 21% stayed overnight at a medical care facility. Our data for prevalence of MHI is greater than those generally obtained from hospital records and indicates a more substantial proportion of individuals with a history of MHI than those reported elsewhere (Bazarian, et al., 2005). We attribute this to being a reflection of the prevalence rate for MHI on the basis of Kay et al.'s (1993) more liberal criteria.

The age at injury for the most recent (15 to 20 years) and for an additional previous trauma (2 years earlier) is consistent with previous findings which have documented a peak occurrence in children and young adults relative to other age ranges (e.g., Cassidy et al., 2004; McKinlay et al., 2008; Ryan et al., 1996; Segalowitz & Lawson, 1995; Dzyundzyak, Baker & Good, 2010). However, in our sample, the gender bias for more males than females reporting a MHI observed in prior findings (e.g., Langlois et al., 2006) was not found. However, proportionally, there were more males in the MHI than in the non-MHI group. This likely reflects the sampling/recruitment bias of the experiment such that more females volunteered to participate in the study consequent on the unequal representation of females over males in the university population.

The major causes of injuries in the study were sport-related activities followed by falling. Other studies (e.g., CIHI, 2006) have placed falls, followed by motor vehicle accidents as the leading causes of MHI among youth and children. However, most epidemiological studies are based on hospital visits and admissions whereas in our study participants were, by definition, selected for the milder injuries and MHIs resulting from sports-related injuries typically involve lesser physical and acceleration-deceleration forces than those resulting from motor vehicles accidents (Ruffolo, Friedland, Dawson, Colantonio & Lindsay, 1999). Finally, the leading causes of injuries and the fact that the majority (41.6%) of participants who were reported to have lost consciousness, experienced LOC for less than 5 minutes, endorsed the view that these injuries met the guidelines outlined by Kay et al.'s (1993) definition and therefore can be considered mild.

Regarding the endorsement of PCS, findings from this study did not support the hypothesis that university students with a history of MHI would report more PCS and would complain about these symptoms more frequently, with greater intensity and for longer durations than non-injured students. While other studies have found PCS differences in these milder samples (e.g., Dzyndziak, Baker & Good, 2010; Baker & Good, 2010), it remains possible that the PCSC (Gouvier, 1992) was not a sufficiently sensitive or reliable measure to detect differences, especially since our population is at the milder end of the spectrum. Further, our participants were well-functioning individuals and may have adapted to any subtle symptoms having been able to adjust to the stressful rigors of academic life such that the PCSC was unable to detect variations in the sample. However, it is also possible that the injuries suffered by our sample did not result in persistent biochemical changes or disruption to brain function such that any PCS in the head injured group was largely resolved within 3 months (e.g., Levin et al., 1987; McCrea et al., 2003; Rutherford et al., 1979).

Interestingly, and as expected, students with prior history of MHI were also found to be physiologically under-aroused relative to their non-injured cohorts at baseline. They also tended to demonstrate lowered HR activity prior to, and during (but not after) making a decision for each type of dilemma but only weakly. This is so despite a tendency to endorse more life stressors, such as the death of a loved one and financial difficulties. These data partially replicate prior findings (e.g., Baker & Good, 2010; van Noordt & Good, 2010) and highlight the dissociation between implicit autonomic measures of affective responsiveness to environmental stressor and explicit measures of affective reactivity to environmental stressors. These results also provide support, albeit subtle, for the hypothesis of possible disruption to the neural pathways of the VMPFC/OFC, the limbic, periaqueductal grey area, and the hypothalamus, regions responsible for physiological and emotional information processing and regulation similar to patterns observed in persons with more moderate to severe VMPFC injuries (Tranel & Damasio, 1994; Koenigs et al., 2007).

In conjunction with differences in physiological arousal at baseline between the MHI and non-MHI groups, findings from this study also lend some support for the Somatic Marker Hypothesis (Damasio, 1996; Damasio, Grabowski, Frank, Galaurda, & Damasio, 1994) because students with prior history of MHI were more willing than their non-injured cohort to report that they would commit emotionally charged direct physical harm violations (that resulted in utilitarian benefits). This is consistent with the view that having reduced physiological arousal interferes with the physiological feedback elicited in emotional situations being able to signal caution, and ultimately influence decisions made, in those circumstances, similar to that found in past investigations (e.g., Bechara, et al., 2000; Chiappetta & Good, 2010; Koenigs et al., 2007; Ciaramelli et al., 2007).

The results in our study are more subtle. For example, there was no interaction effect of the type of moral decision to be made by MHI status; nor were there any significant differences in the time it took to make decisions. Further, there were no differences in physiological arousal noted prior to these emotionally arousing dilemmas excepting for the self-report of arousal state measure. Given that the amount of axonal injury is proportional to the severity level of the impact (Kushner, 1998), it is understandable that individuals with mild trauma demonstrate less profound disruptions in emotional regulation as compared to individuals with more moderate to severe injuries to the VMPFC areas. Further, other brain regions, such as the amygdala which plays a key role in emotional processing, would not be expected to be adversely affected by MHI. Thus, in spite of evidence of lowered physiological responsivity at baseline, unlike persons with severe VMPFC injury, there remain emotional cues available to students with a history of MHI. As such, they were able to experience some amount of the negative emotional consequences (e.g., feeling guilty and regretful) associated with the thought of causing harm to another person, and consequently engaged more frequently in utilitarian decision making. This was reflected in the increased utilitarian post hoc reasoning to these kinds of dilemmas among MHI students relative to non-injured controls, thereby highlighting congruence between "moral choice" and "moral reasoning." Taken together, it appears that a combination of emotional and cognitive mechanism is necessary for moral decision-making (e.g., Greene & Haidt, 2002; Haidt, 2001).

In line with the above, students with a history of MHI, unlike non-injured students, overall did not differentiate among the intentional violations and accidental violations. This is partially consistent with prior evidence indicating that individuals with severe injuries to the VMPFC judged attempted harms as more permissible than non-injured controls (Young et al., 2010), thereby demonstrating a failure to perceive the negative intent of an agents' action. These findings are again consistent with the possibility that students with self-report history of MHI may experience less effectively the aversive emotions associated with perceiving that an individual intends to harm another or not. Thus, it appears that students with a history of self-report MHI may have some difficulties in assigning blame or forgiveness (e.g., being more willing to report that they would commit accidental violations than intentional ones on the basis of the agents intention).

An alternative argument is that MHI students' insensitivity to the intentionality of the violations could be related to difficulties with theory of mind (TOM) or false belief understanding. In other words, a history of MHI, with assumed injuries to OFC/VMPFC, may have engendered deficits in attributing intention across the different types of violations. This seems likely as previous studies have shown deficits in TOM abilities for adolescents with TBI (Tonks et al., 2008). In the current study, we did not measure these abilities but future studies should consider these tasks in order to elucidate the contributions of TOM to moral decision-making.

Findings from the multiple regression analysis predicting direct physical harm violations and injury severity analysis did not offer any unique insights into the moral behavior of students with a history of MHI. However, the multiple regression analysis predicting unintentional non-physical harm transgressions indicates that physiological activity was the most important information needed to make these kinds of decisions. This is understandable due to the less challenging nature of these scenarios. Simply relying on one's gut feelings, which can be tied to the negative experience of breaking societal laws, is sufficient to make these kinds of decisions. Conversely, if these dilemmas were challenging morally ambiguous dilemmas, like direct physical harm, then certain cognitive operations (e.g., shifting attention between competing behavioural alternatives) might have been significant to support decision-making. Support for the mediating effects of physiological arousal might have been found by measuring other socio-emotional processing skills that are important to moral behaviour including recognition of emotional states (e.g., empathy, guilt, and embarrassment) and theory of mind abilities.

The findings that MHI participants did not show any deficits on tasks assessing cognitive flexibility, attention and working memory is not consistent with our hypothesis nor with findings from those of Baker and Good (2009). Indeed, students with a history of self-reported MHI were faster and more accurate on the 'days', and 'number' tasks than non-injured controls. This could suggest that not only did MHI students demonstrate intact executive functioning abilities, but also these abilities were superior to those of non-injured students despite both groups being comparable in terms of level of education and age. The reason for this is unclear; it is possible that MHI students could have come from socially-advantaged backgrounds compared to non-injured students which could have impacted cognitive abilities. In general, the MHI and non-injured students are both cognitively capable as evidenced by their having completed high school and are currently enrolled in university. The injury severity of these students is minor at best, mild at worst, and this is potentially validated by the lack of executive functioning differences across many measures (e.g., Muscara, Catroppa, & Anderson, 2008).

Conclusions and Implications

These results are notable considering that these students are high functioning, academically successful individuals who are participating several years after having sustained a reported injury. Consequently, they challenge the idea that MHI is a transient condition without any persistent effects by providing subtle evidence of long-term physiological and decision-making differences that may have potential emotional, cognitive and social ramifications.

The implication of these findings extends beyond moral judgment and clarifies how students with a history of MHI make moral decisions. Restructuring the moral scenarios to emphasize the 'responsibility' or 'intent' of moral transgression act and their consequent 'level of personal harm outcome' were fairly effective variables in altering the types of decisions people make.

Notwithstanding, there are several limitations of this study that deserve mention. First, due to the small sample size, our analysis did not examine any possible influences of the moderator variable of time since injury. Analyses could be conducted to determine if decision making, cognitive performance were related to time since injury.

Secondly, our analysis did not examine, measure, or otherwise rule out the possible influence of premorbid behavioural characteristics on performance. Individuals who have sustained injuries (e.g., sports, falls) may be more likely to engage in riskier, sensation-seeking activities preinjury, thereby, more likely to sustain an MHI at all, and our results on decision-making may be simply a reflection of this riskier, less physiologically aroused, and less 'emotionally-guided', population as opposed to implicating anything about trauma-based neural disruption per se. Similarly, decision-making performance could be linked to individual differences in personality. For instance, individuals with higher levels of psychological well-being have been found to take a longer time to evaluate negative versus neutral information. Moreover, higher psychological well-being was associated with greater activation in the ventral anterior cingulate cortex for negative relative to neutral information (van Reekum et al., 2007). Thus, the collection of pre-injury measures of participants' performance, socio-economic status and/or confirmatory injury indicators, individual differences in personality are recommended.

Finally, the characteristics of our participants and the sample size are also short-comings of the study. We chose a small group of high functioning individuals using a very liberal definition to investigate the effects of MHI. Although, our participants demonstrated the same neurobiological profile observed in individuals with moderate to severe injuries, we cannot say for certain that these findings are generalizable to the wide spectrum (from uncomplicated to complicated MHI) of MHI injuries. Therefore, ongoing replication studies using larger samples including a wider range of injury severity are needed to confirm the existence of these deficits and possible consequences of having these difficulties.

Nonetheless, by targeting a well-functioning, asymptomatic university sample with prior history of MHI with arguably no persistent complaints of PCS, our findings indicate that even mild trauma can engender subtle long-term differences in moral decision-making and physiological responsiveness. Students with a reported previous mild traumatic injury were physiologically less responsive on measures of sympathetic nervous system arousal and were more likely to make decisions that reflect a lessened emotional effect towards the intentionality of moral transgressions relative to their cohorts.

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Appendix A1: Application for access to the Brock University Psychology Research Pool

BROCK UNIVERSITY
Department of Psychology

Application for Access to the Psychology Research Pool

All studies posted to the Psychology Research Pool website must have Research Ethics Board (REB) approval.

INSTRUCTIONS:
Please complete the information below about your study and then email this form to (lindap@brocku.ca) with the subject line RESEARCH POOL. Using the information you have provided I will create an account for you on the Psychology Research Pool website. The system will automatically email you your login and password information. You will then be able to login to the system and input all the information about your study. The only information I will be inputting will be the researcher name, contact information, title of study and REB number. You will be responsible for setting up the rest of the study including appointment times, rooms, etc.

****

NAME OF RESEARCHER WHO WILL CONDUCT MOST OF THE TESTING:
Julia Williams
Jordan Atkinson
Tanvi Sharan

RESEARCHER CONTACT INFORMATION: TELEPHONE NUMBER: (905) 688-5550
OFFICE NUMBER: PL 621 ext. 3556, 5523
EMAIL: jw08tu@brocku.ca
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FACULTY ADVISOR (if applicable): Dr. Dawn Good
Dawn.Good@brocku.ca
(905) 688-5550 ext. 3869

TITLE OF STUDY: Decision Making and Individual Differences

BRIEF DESCRIPTION: This study is investigating factors that influence decision making and how those factors are mitigated by individual differences. Participants will be asked to complete various questionnaires regarding personality factors and health, and measures of physiological arousal will be recorded during one session for approximately 1.5 hours.

IS THIS A TWO PART STUDY? no
LENGTH OF STUDY: 1.5 hours
SELECTION CRITERIA: Fluent in English
ETHICS APPROVAL NUMBER (REB #): 09-120
DEADLINES: Sign-up: 24 hour (s) before appointment
CANCELLATION: 24 hour (s) before appointment (deadlines that occur on a Saturday or Sunday will be moved back to Friday)

Appendix A2: Clearance Letter from Research Ethics Board (REB)

DATE: 12/17/2009

FROM: Michelle McGinn, Chair

Research Ethics Board (REB)

TO: Dr. Dawn Good, Psychology

Julia Williams, Jordan Atkinson, Tanvi Sharon

FILE: 09-102 GOOD

Masters Thesis/Project

TITLE: Decision Making and Individual Differences

The Brock University Research Ethics Board has reviewed the above research proposal.

DECISION: Accepted as clarified

This project has received ethics clearance for the period of December 17, 2009 to August 31, 2010 subject to full REB ratification at the Research Ethics Board's next scheduled meeting. The clearance period may be extended upon request. ***The study may now proceed.***

Please note that the Research Ethies Board (REB) requires that you adhere to the protocol as last reviewed and cleared by the REB. During the course of research no deviations from, or changes to, the protocol, recruitment, or consent form may be initiated without prior written clearance from the REB. The Board must provide clearance for any modifications before they can be implemented. If you wish to modify your research project, please refer to http://www.brocku.ca/research/policies-and-forms/forms to complete the appropriate form Revision or Modification to an Ongoing Application.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

The Tri-Council Policy Statement requires that ongoing research be monitored. A Final Report is required for all projects upon completion of the project. Researchers with projects lasting more than one year are required to submit a Continuing Review Report annually. The Office of Research Services will contact you when this form *Continuing Review/Final Report* is required.

Please quote your REB file number on all future correspondence.

MM/mb

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Appendix A3: Brock Neuropsychology Cognitive Research Laboratory Demographic Questionnaire

Q4- EDL

Please fill in or circle an answer for each of the following. If you have any questions regarding clarification please ask the researcher. Thank you for your time and effort!

1. How old are you? ____

2. Gender? M___ F____

3. What is the highest level of education you have presently completed?
   a Less than high school
   b. High School/Grade 12
   c. University 1 2 3 4 4+ (Years)
   d. College 1 2 3 4 4+

4. What is your major (e.g. English, Psychology, Science)? ______________________

5. Handedness
   a. Right
   b. Left
   c. Both

6. Have you ever been hospitalized for (circle any that apply):
   a. Fractures Y N
   b. Illness Y N
   c. Surgery Y N
   d. Neurological complications Y N
   e. Other Y N

   If you answered Y to any of the above, briefly please provide details:
   e.g. How old were you? How did it happen?
   ____
   ____
   ____

7. Have you ever been diagnosed with a neurological condition? Y N

8. Have you ever been diagnosed with a psychiatric condition? Y N

9. Are you currently taking any prescribed medications for a neurological or psychiatric condition? Y N

   a. If Yes, if you wish to disclose what medication please do so: ____________________

10. Have you ever sustained an injury to your head with a force sufficient to alter your consciousness (e.g. dizziness, vomiting, seeing stars, or loss of consciousness, or confusion)? Y N
    [If you answered **no** to this question you may move ahead to question 22]

If yes to question 10, please answer the following questions (if you have had more than one injury, please refer to the *most recent* time you injured your head):

11. If you answered yes to question 10, did you experience these symptoms for more than 20 minutes? Y N

12. Did you experience a loss of consciousness associated with the head injury? Y N

    i. If so, how long was the loss of consciousness?
        i. [ ] < 5 minutes
        ii. [ ] < 30 minutes
        iii. [ ] < 24 hours
        iv. [ ] < 1 week
        v. [ ] < 1 month
        vi. [ ] > 1 month

13. How did you injure your head?

    i. [ ] Motor vehicle collision
    ii. [ ] Sports-related injury
    iii. [ ] Falling
    iv. [ ] Other Please Specify:________________________________

14. Please briefly describe the incident during which the head injury occurred:

____

____

____

15. Please answer the following questions:

    a. Did the head injury result in a concussion? Y N

    b. Did it require stitches? Y N

    c. Did you receive medical treatment for your injury? Y N

    d. Did you stay overnight at a medical care facility? Y N

e. Have you ever been diagnosed or classified as having a Learning Disability?
Y N

f. Approximately how old were you at the time ___

g. How many months or year(s) have past since you hit your head? ___

16. Have you sustained *more than one* injury to your head with a force sufficient to alter your consciousness (e.g. dizziness, vomiting, seeing stars, or loss of consciousness, or confusion)? Y N

a. **If yes**, how many times? ___

17. **If you answered yes to question 16**, did you experience these symptoms for more than 20 minutes? Y N

If you responded yes to question 16, please answer the following with respect to your *least recent* head injury:

18. Did you experience a loss of consciousness associated with the least recent head injury?
Y N

i. If so, how long was the loss of consciousness?
   - i. [ ] < 5 minutes
   - ii. [ ] < 30 minutes
   - iii. [ ] < 24 hours
   - iv. [ ] < 1 week
   - v. [ ] < 1 month
   - vi. [ ] > 1 month

19. How did you injure your head?

   - i. [ ] Motor vehicle collision
   - ii. [ ] Sports-related injury
   - iii. [ ] Falling
   - iv. [ ] Other Please Specify:______________________________

20. Please briefly describe the incident during which the least recent head injury occurred:

____

____

____

21. Please answer the following questions:

a. Did the head injury result in a concussion? Y N

b. Did it require stitches? Y N

c. Did you receive medical treatment for your injury? Y N

d. Did you stay overnight at a medical care facility? Y N

e. Approximately how old were you at the time ___

f. How many months or year(s) have past since you hit your head? ___

22. Have you ever experienced any other neural trauma (e.g. stroke, anoxia)? Y N
   a. **If yes**, please explain:

____

____

23. Do you smoke cigarettes? Y N

   If yes, approximately how many a day? ______

24. Do you regularly engage in consuming alcohol? Y N

   a. If yes, how many drinks per week do you consume? _________
   b. On average how many drinks would you consume in one outing? _________

25. Do you engage in recreational drug use (e.g. smoke marijuana, drop ecstasy, etc.)? Y N

26. Did you consume caffeine today (e.g. coffee, tea, energy drink, chocolate)? Y N

   a. **If yes**, how much?
      1 2 3 more than 3

   b. **If yes**, how much time has past since you last consumed caffeine today?

      Less than 1 hour More than 1 hour

27. Do you have sensitivity to perfumes or scents? Y N

   If yes, please rate your sensitivity:

Not at all								Very
1	2	3	4	5	6	7	8	9

28. Do you have a valid driver's license? Y N

a. **If yes**, how long have you had a driver's license? 1-3 years 4-6 years 7+ years

29. Do you wear glasses or contacts? Y N

30. Do you live: on your own with roommates other

with parents/guardians with partner

31. How many university credits are you taking this semester?

0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6

32. On a scale of 1 to 9 rate your enjoyment of academics:

Not at all Very
1 2 3 4 5 6 7 8 9

33. Have you ever received any extra assistance during your educational history? Y N

Please circle any that apply and indicate when you received the assistance:
E = Elementary school H = High school U = University

a. Learning resource teacher E H U
b. Tutor E H U
c. Educational assistant E H U
d. Speech Language Pathologist E H U
e. Occupational Therapist E H U
f. Physical Therapist E H U
g. Other: Please Specify:__________________________ E H U

34. On a scale of 1 to 9 rate your enjoyment of your life situation:

Not at all Very
1 2 3 4 5 6 7 8 9

35. On a scale of 1 to 9 how stressful would you rate your day-to-day life:

Not at all Very
1 2 3 4 5 6 7 8 9

36. What extracurricular sport(s) did you play in:

a. Elementary school:
    i. please describe/name the sport(s) – indicate if it was recreational (R) or competitive (C)___________________________________

ii. How often do you play sports (per week)?___________________

b. High school:
   i. please describe/name the sport(s) – indicate if it was recreational (R) or competitive (C)________________________________

   ii. How often do you play sports (per week)?___________________

c. Currently play sports in University
   i. please describe/name the sport(s) – indicate if it was recreational (R) or competitive (C)________________________________

   ii. How often do you play sports (per week)?___________________

37. Do you exercise regularly? Y N

a. **If yes**, how many times a week do you exercise? _______

Please describe:____

____

38. When you ride a bike/skate/etc. do you wear a helmet? Y N NA

39. Do you regularly engage in relaxation techniques (e.g. deep breathing or yoga): Y N

a. **If yes**, how many times a week do you engage in relaxation methods?_______

Please describe:____

40. Was last night's sleep typical for you? Y N

If No, what was different (better, worse) ? ____________________________

Why was it different? (stress, room temperature, noise, etc.)

____

Please indicate how well you slept last night by circling a number:

Worst Possible Sleep	1	2	3	4	5	6	7 Best Possible Sleep

Please indicate how you feel right now by circling a number:

Very Sleepy	1	2	3	4	5	6	7 Very Alert

41. Have you had anything out of the ordinary occur in the past day or so? Y N
If yes, please explain:

____

____

____

42. Circle any of the following that apply to your experience over the past 6 months:

Moved	Death of a family member
New Job	Death of a close friend
Loss of Job	Financial Difficulties
Loss of Relationship	Illness of someone close to you
New Relationship	Personal Illness/Injury
Reconciliation with partner	New Baby
Reconciliation with Family	Wedding/ Engagement (self)
Divorce (of self or parents)	Vacation
Entered 1st year at university	Disrupted Sleep

43. Please indicate how your day has been so far by circling a number:

Calm	1	2	3	4	5	6	7	8	9	10	Busy
Pleasant	1	2	3	4	5	6	7	8	9	10	Unpleasant
NOT Stressful	1	2	3	4	5	6	7	8	9	10	VERY Stressful

Appendix A4: Post-Concussive Syndrome Checklist

Post-Concussion Syndrome Checklist (PCSC)

NAME________________________ DATE__________________

Please rate the frequency, intensity and duration of each of the following symptoms based on how they have affected you today according to the following scale:

FREQUENCY	INTENSITY	DURATION
1 = Not at all	1 = Not at all	1 = Not at all
2 = Seldom	2 = Vaguely present	2 = A few seconds
3 = Often	3 = Clearly present	3 = A few minutes
4 = Very often	4 = Interfering	4 = A few hours
5 = All the time	5 = Crippling	5 = Constant

	FREQUENCY	INTENSITY	DURATION
Headache	______	______	______
Dizziness	______	______	______
Irritability	______	______	______
Memory Problems	______	______	______
Difficulty Concentrating	______	______	______
Fatigue	______	______	______
Visual Disturbances	______	______	______
Aggravated by Noise	______	______	______
Judgment Problems	______	______	______
Anxiety	______	______	______

Thank you for your time and effort in the completion of this form.

A5. Moral Decision Making Stimuli

Moral Decision Making Task

Below you will be presented with a series of dilemmas in which you must judge how likely it would be that you would carry out a particular course of action. Try to actively place yourself in the scenario (i.e., act as if the scenario presented and the decisions made are a reality for you). Only focus on the information given in the scenario and do not create alternatives or use "what ifs" to alter the nature of the situation.

Deliberate Physical Harm

1. Preventing the Spread

You are a doctor. One of your patients, whom you diagnosed as HIV positive, is about to be released from the hospital. He has told you, in the confidence of your doctor-patient relationship, that he intends to infect as many people as possible with HIV starting that evening.

Because you are bound by doctor-patient confidentiality, there is no legal way to stop this man from carrying out his plan. It occurs to you that you could contaminate his medication with an untraceable poison that will kill him before he gets a chance to infect others. You execute your plan in contaminating his medication and the patient dies without getting a chance to infect others.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Crying Baby

Enemy soldiers have taken over your village. They have orders to kill all remaining civilians. You and some of your townspeople have sought refuge in the cellar of a large house. Outside you hear the voices of soldiers who have come to search the house for valuables.

Your baby begins to cry loudly. You cover his mouth to block the sound. If you remove your hand from his mouth his crying will summon the attention of the soldiers who will kill you, your child, and the others hiding out in the cellar. To save yourself and the others you must smother your child to death. After contemplating the dilemma, you use your free hand to smother the baby. Your baby dies within a few minutes of struggling and your compatriots are saved.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Safari

You and a group of ecologists are studying the wildlife in a remote stretch of jungle when you are captured by a group of paramilitary terrorists. You are held hostage for several days. One of the terrorists takes a liking to you. He informs you that his leader intends to kill you and the rest of the hostages the following morning.

He says that he is willing to help you escape, but that he needs some assurance that you will not go to the police. He devises the following plan. He will videotape you while you kill one of your sleeping colleagues. The tape will ensure your silence, making it possible for you to escape. After contemplating the terrorist's proposal you advise him of your agreement. Later that night, while everyone is sleeping, you use a knife supplied by the terrorist to stab one of your colleagues while being videotaped. Your colleague dies and you are free to go home.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. Modified Lifeboat

You are on a cruise ship when there is a fire on board, and the ship has to be abandoned. The lifeboats are carrying many more people than they were designed to carry. The lifeboat you're in is sitting dangerously low in the water-a few inches lower and it will sink.

The seas start to get rough, and the boat begins to fill with water. If nothing is done it will sink before the rescue boats arrive and everyone on board will die. However, there is an injured person who will not survive in any case. If you throw that person overboard the boat will stay afloat and the remaining passengers will be saved. After weighing the situation, you push the injured person overboard. The injured person drowns and the lives of the other persons are saved because the boat had become lighter.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Unintentional Physical Harm

1. Environmental Policy B2

You are a member of a government legislature. The legislature is deciding between two different policies concerning environmental hazards.

Policy A has a 90% chance of causing no deaths at all and has a 10% chance of causing 1000 deaths. Policy B has an 88% chance of causing no deaths and a 12% chance of causing 10 deaths. On the day of the voting, you decide to vote for Policy A. Sure enough, the implementation of the policy A. some years later caused the deaths of 1000 people.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Country Road

You are a firefighter and the only driver of the local Fire Department, speeding along a country road in response to a 3-alarm emergency call when you see something in the way of the road, extending from some roadside bushes. You pull over and encounter a man whose legs are clearly broken. The man explains that he has had an accident while hiking and asks you to take him to a nearby hospital.

Your initial inclination is to help this man, who will probably lose his legs if he does not get to the hospital soon. However, if you give this man a lift, you will seriously delay the fire department's response to the bush fire. After weighing the situation, you decide to leave the man by the side of the road thereby causing the loss of the man's legs. However, you were able to respond effectively to the fire.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Standard Trolley

You are at the wheel of a runaway trolley quickly approaching a fork in the tracks. On the tracks extending to the left is a group of five railway workmen. On the tracks extending to the right is a single railway workman.

If you do nothing the trolley will proceed to the left, which will cause the deaths of the five workmen. The only way to avoid the deaths of these workmen is to hit a switch on your dashboard that will cause the trolley to proceed to the right, causing the death of the single workman. After contemplating the situation, you decide to hit the switch. Sure enough, the trolley proceeds to the right and kills the workman thereby saving the lives of the five railway workmen.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. Eyes

In the future, you are a veteran of a war during which both of your eyes were destroyed. Due to recent medical advances, it is now possible to perform eye transplants, but, much to your anger and amazement, there are no willing donors.

A sympathetic black-market surgeon offers to help you. If you hire him, he and his associates will kidnap a randomly selected stranger, carve out one of his eyes, and transfer it to you. You really want to see again and as a result you decide to hire the black-market surgeon to help you.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Deliberate Non-Physical Harm

1. Donation
You are at home one day when the mail arrives. You receive a letter from a reputable international aid organization. The letter asks you to make a donation of two hundred dollars to their organization. The letter explains that a two hundred-dollar donation will allow this organization to provide needed medical attention to some poor people in another part of the world. After considering the amount of money that you can save for that week, you decided against making a donation to this organization.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Lost Wallet

You are walking down the street when you come across a wallet lying on the ground. You open the wallet and find that it contains several hundred dollars in cash as well the owner's driver's license.
From the credit cards and other items in the wallet it's very clear that the wallet's owner is wealthy. You, on the other hand, have been hit by hard times recently and could really use some extra money. After contemplating this situation, you decide to send the wallet back to the owner without the cash thereby keeping the cash for yourself.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Speedboat
While on vacation on a remote island, you are fishing from a seaside dock. You observe a group of tourists board a small boat and set sail for a nearby island. Soon after their departure you hear over the radio that there is a violent storm brewing, a storm that is sure to intercept them.

The only way that you can ensure their safety is to warn them by borrowing a nearby speedboat. The speedboat belongs to a miserly tycoon who would not take kindly to your borrowing his property. However, you decide to borrow the speedboat in order to warn the tourists about the storm.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. Sculpture

You are visiting the sculpture garden of a wealthy art collector. The garden overlooks a valley containing a set of train tracks. A railway workman is working on the tracks, and an empty runaway trolley is heading down the tracks toward the workman.

The only way to save the workman's life is to push one of the art collector's prized sculptures down into the valley so that it will roll onto the tracks and block the trolley's passage. Doing this will destroy the sculpture. After contemplating the situation, you decide to push one of the art collector's prize sculptures, thereby causing it to block the trolley's passage.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Unintentional Non-Physical Harm

1. Stock Tip

You are a management consultant working on a case for a large corporate client. You have access to confidential information that would be very useful to investors. You have a friend who plays the stock market. You owe this friend a sizable sum of money.

By providing her with certain confidential information you could help her make a lot of money, considerably more than you owe her. If you did this, she would insist on canceling your debt. Releasing information in this way is strictly forbidden by federal law. While browsing over the information in your office your friend walked in and glanced at the files. As a result, your friend recognizes that she could gain an advantage in investing in this corporate client.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Illegal Lunch

You are a lawyer working on a big case. The judge presiding over the trial happens to be someone you knew from law school. The two of you were rather friendly back then, but now, decades later, it seems that your old friend barely remembers you.

You're quite sure that if you were to talk to him over lunch, you could jog his memory and he would begin to see you as an old buddy, which would be very good for your work on this case. It's illegal for judges and lawyers working on the same case to meet socially. However, while having lunch at a restaurant, the judge walked in and the restaurant owner introduced him to you. While talking, you were reacquainted as old buddies and this resulted in putting your case at an advantage.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Taxes

You are the owner of a small business trying to make ends meet. It occurs to you that you could lower your taxes by pretending that some of your personal expenses are business expenses.

For example, you could pretend that the stereo in your bedroom is being used in the lounge at the office, or that your dinners out with your wife are dinners with clients. While your accountant was completing the tax forms, you were experiencing a stressful day at work. This affected your memory and caused you to mistake certain personal items for business expenses. As a result, your taxes were lowered.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. Resume

You have been trying to find a job lately without much success. You figure that you would be more likely to get hired if you had a more impressive resume.

Your sister is very sympathetic to your situation. One evening while taking a nap, she decides to put some false information on your resume in order to make it more impressive. As a result of this, you managed to get hired, beating out several candidates who were more qualified than yourself.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Unintentional Non-moral

1. Plant Transport

You are bringing home a number of plants from a store that is about two miles from your home. The trunk of your car, which you've lined with plastic to catch the mud from the plants, will hold most of the plants you've purchased.

You could bring all the plants home in one trip, but this would require putting some of the plants in the back seat as well as in the trunk. By putting some of the plants in the back seat you will ruin your fine leather upholstery which would cost thousands of dollars to replace.

While putting some of the flowers in the trunk you receive a call from your wife calls who informs you about an accident involving your daughter. You drive home in a hurry in a bid to check on your daughter. You subsequently realize that you left some of the flowers at the store. As a result, you had to make another trip to the store for the flowers thereby preserving the fine leather upholstery of your car seat.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Train or Bus

You need to travel from New York to Boston in order to attend a meeting that starts at 2:00 PM. You can take either the train or the bus.

The train will get you there just in time for your meeting no matter what. The bus is scheduled to arrive an hour before your meeting, but the bus is occasionally several hours late because of traffic. It would be nice to have an extra hour before the meeting, but you cannot afford to be late. While waiting at the station, a lady standing next to you faints and you also notice that she has stopped breathing. You spend the next thirty minutes administering CPR and due to the passage of time you had no choice but to take the train instead of the bus. As a result you were not late for your meeting.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Generic Brand

You have a headache. You go to the pharmacy with the intention of buying a particular name-brand headache medicine. When you get there you discover that the pharmacy is out of the brand you were looking for.

The pharmacist, whom you've known for a long time and in whom you have a great deal of trust, tells you that he has in stock a generic product which is, in his words, "exactly the same" as the product you had originally intended to buy. While listening to the pharmacist, you suddenly remember an urgent meeting with your boss which is schedule to start within the next ten minutes. As a result, you abort the search for the name-brand medication and purchase the generic brand instead.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. New Job

You have been offered employment by two different firms, and you are trying to decide which offer to accept.

Firm A has offered you an annual salary of $100,000 and fourteen days of vacation per year. Firm B has offered you an annual salary of $50,000 and sixteen days of vacation per year. The two firms and the two positions are otherwise very similar. On day you are schedule to sign the contract with Firm A you are inform by the adoption agency that your application to adopt an orphan has been approved. As a result, you had to take Firm B's offer which allows you to have more vacation days to spend with your new child.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Deliberate Non-Moral

1. Brownies

You have decided to make a batch of brownies for yourself. You open your recipe book and find a recipe for brownies.

The recipe calls for a cup of chopped walnuts. You don't like walnuts, but you do like macadamia nuts. As it happens, you have both kinds of nuts available to you. In order to avoid eating walnuts you decide to substitute macadamia nuts for walnuts in the recipe.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

2. Computer

You are looking to buy a new computer. At the moment the computer that you want costs $1000. A friend who knows the computer industry has told you that this computer's price will drop to $500 next month.
If you wait until next month to buy your new computer you will have to use your old computer for a few weeks longer than you would like to. Nevertheless you will be able to do everything you need to do using your old computer during that time. In order to save $500 on the purchase of a new computer you decide to use your old computer for a few more weeks.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

3. Survey

A representative of a reputable, national survey organization calls you at your home while you are having a quiet dinner by yourself.

The representative explains that if you are willing to spend a half an hour answering questions about a variety of topics her organization will send you a check for $200. In order to earn $200 you decide interrupt your dinner to participate in the survey.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

4. Food Prep

You are preparing pasta with fresh vegetables, and you are deciding on the order in which you will do the various things you need to do. You are in a big hurry.
At the moment you have a slight urge to cut vegetables. If you first start the water boiling and then cut the vegetables you will be done in twenty minutes. If you cut the vegetables and then start the water boiling you will be done in forty minutes. In order to satisfy your slight urge to cut the vegetables you decide to cut the vegetable first and then start the water boiling.

0	1	2	3	4
Not at all	Slightly	Moderately	Very	Certain

Appendix B: Tables for descriptive statistics and statistical analyses

Table 1

Summary Statistics of Demographic Characteristics for Order of Dilemmas

	Order 1 (n = 14)		Order 2 (n = 12)		Order 3 (n =10)		Order 4 (n = 12)		
	n	%	*n*	%	*n*	%	*n*	%	χ^2 (*df*); *p*
Gender									5.45 (3); .141
Female	10	34.5	9	31.0	6	20.7	4	13.8	
Male	4	21.1	3	15.8	4	21.1	8	42.1	
Education									6.80 (9); .658
Less than high sch.	0	0.0	0	0.0	1	100.0	0	0.0	
High sch. graduate	3	25.0	3	25.0	3	25.0	3	25.0	
College graduate	2	66.7	1	33.3	0	0.0	0	0.0	
Some university	9	29.0	8	25.8	6	19.4	8	25.8	
Age (years)									0.33 (3,44); .80
M (SD)	20.64	2.92	20.67	2.70	21.30	4.29	20.0	2.13	

Table 4

Summary Statistics for Demographic Characteristics for Participants with MHI and No MHI

	MHI (n = 24)		No MHI (n = 24)		
	n	%	n	%	χ^2 (df); p
Drug use					0.56 (1); .450
Yes	5	20.83	7	30.43	
No	19	79.16	16	69.56	
Sensitivity to perfume					3.27 (2); .194
Yes	3	12.50	8	33.3	
No	21	87.50	16	66.7	
Other neural trauma					0.97 (1); .323
Yes	1	4.54	0	.0	
No	21	95.45	21	100.0	
Educational assistance					0.18 (1); .671
Yes	11	47.8	10	41.7	
No	12	52.2	14	58.3	
Occupational therapist					no statistics
High school	1	100.0	0	0.0	
Learning resource teacher					no statistics
Elementary	3	60.0	2	40.0	

Table 4 Continued

Summary Statistics for Demographic Characteristics for Participants with MHI and No MHI

Tutor					0.78 (2); .675
Elementary	3	30.0	1	12.5	
High school	5	50.0	5	62.5	
University	2	20.0	2	25.0	
Physical therapist					no statistics
High school	1	50.0	0	0.0	
University	1	50.0	0	0.0	
Educational assistant					no statistics
University	1	100.0	0	0.0	
Living					1.68 (4); .793
Own	2	8.3	2	8.3	
Roommates	14	58.3	12	50.0	
Parents	5	20.8	7	29.2	
Partner	3	12.5	2	8.3	
Other	0	0.0	1	4.2	
Wear glasses					2.08 (1); .149
Yes	10	41.7	15	62.5	
No	14	58.3	9	37.5	

Table 5

Summary Statistics for Arousal Indicators for Participants with MHI and No MHI

	MHI (n = 24)		No MHI (n = 24)		
Variable	*M*	*SD*	*M*	*SD*	*F* (*df*); *p*
Current mood	4.62	1.37	5.17	1.09	2.28 (1, 46); .13
Current activity level	4.88	2.86	7.17	10.34	1.09 (1, 46); .30
Current stress	3.96	2.36	4.33	2.39	0.29 (1, 46); .58
Sleep quality	4.54	1.28	4.96	1.29	1.21 (1, 46); .27
Current credits undertaken	3.75	1.36	3.85	1.31	0.07 (1, 46); .78

Table 6

Summary Statistics for Perceived Enjoyment of Life and Academic Situation for Participants with MHI and No MHI

	MHI ($n = 24$)		No MHI ($n = 24$)		
Variable	*M*	*SD*	*M*	*SD*	*F* (*df*); *p*
Enjoyment of life	7.08	1.47	6.78	1.62	0.44 (1, 46); .50
Number of credits taken	3.75	1.36	3.85	1.31	0.07 (1, 46); .78
Enjoyment of academics	6.17	1.90	5.62	1.86	0.99 (1, 46); .32

Table 7

Summary Statistics for Order of Dilemmas by Time of Day Tested for MHI participants

	Order 1		Order 2		Order 3		Order 4	
Variable	*n*	%	*n*	%	*n*	%	*n*	%
Time of day tested								
Morning	0	0.0	2	8.3	3	12.5	1	4.2
Afternoon	7	38.9	4	16.7	2	8.3	5	20.8

Table 8

Summary Statistics for Order of Dilemmas by Time of Day Tested for No MHI participants

	Order 1		Order 2		Order 3		Order 4	
Variable	*n*	%	*n*	%	*n*	%	*n*	%
Time of day tested								
Morning	0	0.0	1	4.2	2	8.3	1	4.2
Afternoon	7	29.2	4	21.2	3	12.5	5	20.8
Evening	0	0.0	1	4.2	0	0.0	0	0.0

Table 9

Descriptive Statistics for Baseline Arousal (HR Activity) by Time of Day Tested

Variable	*M*	*SD*
Time of day		
Morning	75.25	9.69
Afternoon	74.35	18.25
Evening	92.51	-

Table 25

Analysis of Variance of Anticipatory HR Activity (Frequency) by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Dilemma	5	12.28	1.29	.27	.02
Dilemma x MHI	5	10.18	1.07	.37	.34
Error	225				
		Between subjects			
MHI	1	1335.98	3.58	.065	.074
Error	45				

Table 26

Analysis of Variance of HR Activity (Frequency) During the Onset of Dilemma by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	η
		Within subjects			
Dilemma	5	12.28	1.29	0.26	.02
Dilemma x MHI	5	10.18	0.61	0.60	.01
Error	225				
		Between subjects			
MHI	1	1335.98	3.58	0.06	.07
Error	45				

Table 27

Analysis of Variance of HR Activity (Frequency) During the Responses to Dilemmas by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	η
		Within subjects			
Dilemma	5	90.83	1.52	.18	.033
Dilemma x MHI	5	139.2	2.33	.322	.026
Error	225				
		Between subjects			
MHI	1	914.11	2.59	.114	.055
Error	45				

Table 28

Analysis of Variance of HR Activity (Frequency) During the Response Reaction to Dilemmas by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	η
		Within subjects			
Dilemma	5	65.19	2.55	.029	.054
Dilemma x MHI	5	30.08	1.17	.321	.026
Error	225				
		Between subjects			
MHI	1	914.11	2.58	.114	.055
Error	45				

Table 29

Analysis of Variance of Self-report of Arousal State by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Dilemma	5	14.55	16.59	.000	.278
Dilemma x MHI	5	1.08	1.23	.293	.028
Error	215				
		Between subjects			
MHI	1	13.56	0.36	.360	.020
Error	43				

Table 30

Analysis of Variance of Dilemma Ratings by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Intention	1	0.13	0.44	.506	.010
Intention x MHI	1	0.12	0.40	.528	.009
Error	46				
Moral	2	17.86	38.58	.000	.456
Moral x MHI	2	0.92	1.99	.141	.042
Error	92				
Intention x Moral	2	0.44	1.88	.158	.039
Intention x Moral x MHI	2	1.16	4.96	.009	.097
Error	92				
		Between subjects			
MHI	1	1.10	0.89	.348	.019
Error	46				

Table 31

Analysis of Variance of Dilemma Ratings by No MHI Group and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Moral	2	12.38	27.39	.000	.544
Error	46				
Intention	1	0.00	0.00	.979	.000
Error	23				
Moral x Intention	2	1.47	8.02	.001	.259
Error	46				

Table 32

Analysis of Variance of Dilemma Ratings by MHI Group and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Moral	2	6.41	13.52	.000	.370
Error	46				
Intention	1	0.26	0.70	.411	.030
Error	23				
Moral x Intention	2	0.13	0.46	.633	.020
Error	46				

Table 33

Analysis of Variance of Unintentional Dilemma Ratings by No MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Unintentional	2	4.14	14.09	.000	.380
Error	46				

Table 34

Analysis of Variance of Deliberate Dilemma Ratings by No MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Deliberate	2	13.06	28.38	.000	.552
Error	46				

Table 36

Analysis of Variance of Reaction Time to Dilemmas by MHI Groups and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Moral	2	2.60	3.34	.040	.068
Moral x MHI	2	2.32	2.97	.056	.061
Error	92				
Intentionality	1	23.31	33.30	.000	.420
Intentionality x MHI	1	3.59	5.13	.028	.100
Error	46				
Intention x Moral	2	5.97	12.54	.000	.214
Intention x Moral x MHI	2	2.02	4.24	.017	.084
Error	92				
		Between subjects			
MHI	1	1.19	0.28	.598	.006
Error	46				

Table 37

Analysis of Variance of Reaction Time to Moral Dilemma by No MHI Group and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Moral	2	4.81	5.61	.007	.196
Error	46				
Intention	1	22.61	37.90	.000	.622
Error	23				
Moral x Intention	2	3.43	7.67	.001	.250
Error	46				

Table 38

Analysis of Variance of Reaction Time to Dilemmas by MHI Group and Type of Dilemma

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Moral	2	0.12	0.17	.838	.008
Error	46				
Intention	1	4.29	5.34	.030	.189
Error	23				
Moral x Intention	2	4.55	9.03	.000	.282
Error	46				

Table 39

Analysis of Variance of Reaction Time to Unintentional Dilemmas by No MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Unintentional	2	8.07	8.71	.001	.275
Error	46				

Table 40

Analysis of Variance of Reaction Time to Deliberate Dilemmas by No MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Deliberate	2	0.17	0.46	.633	.020
Error	46				

Table 41

Analysis of Variance of Reaction Time to Unintentional Dilemmas by MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Unintentional	2	3.09	4.51	.016	.164
Error	46				

Table 42

Analysis of Variance of Reaction Time to Deliberate Dilemmas by MHI Group

Source	*df*	*MS*	*F*	*p*	*n*
		Within subjects			
Deliberate	2	1.58	3.03	.058	.116
Error	46				

Table 43

Descriptive Statistics for Social Problem Solving Inventory Measure for MHI and No MHI Groups

	MHI		No MHI			
Variable	*M*	*SD*	*M*	*SD*	*F* (1, 46)	*p*
Positive problem orientation	2.61	0.79	2.30	0.95	1.49	.22
Negative problem orientation	1.43	0.92	1.87	1.10	2.23	.14
Rational problem solving	2.34	1.00	2.39	0.80	0.04	.83
Impulsivity/carelessness style	1.33	0.65	1.33	0.81	0.00	.96
Avoidance style	1.57	0.74	1.55	0.82	0.01	.91
Problem definition & formulation	2.42	0.92	2.39	0.94	0.01	.91
Generation of alternative solution	2.35	0.72	2.51	0.90	0.45	.50
Decision making	2.54	0.86	2.34	0.81	0.68	.41
Solution implementation & veri.	2.31	0.86	2.32	0.86	0.00	.98
Total SPSI	12.29	3.72	11.45	3.88	0.58	.44

Table 44

Descriptive Statistics for Mental Control Measure for MHI and No MHI Groups

	MHI		No MHI			
Variable	*M*	*SD*	*M*	*SD*	*F* (1, 46)	*p*
MC number response time	4.13	1.36	4.95	0.88	6.17	.01
MC number accuracy	3.83	0.87	3.33	0.64	5.17	.02
MC alphabet response time	4.63	0.92	0.94	21.33	0.71	.40
MC alphabet accuracy	3.38	0.65	2.92	1.25	2.55	.11
MC days response time	2.17	0.56	2.75	0.80	8.47	.00
MC days Accuracy	3.17	0.56	2.79	0.50	5.84	.02
MC months response time	4.38	1.21	4.51	1.19	0.15	.69
MC months accuracy	2.83	1.31	2.83	1.01	0.00	1.00
MC number backwards resp. time	6.00	1.64	6.94	1.76	3.67	.06
MC number backwards accuracy	3.88	0.90	3.58	1.14	0.96	.33
MC days backwards resp. time	3.54	0.88	3.65	0.78	0.21	.64
MC days backwards accuracy	4.33	0.92	4.29	0.69	0.32	.86
MC months backwards resp. time	11.08	4.14	11.35	4.86	0.43	.83
MC months backwards accuracy	3.62	1.47	3.50	1.50	0.85	.77
MC switching response time	16.92	6.32	18.69	7.57	0.77	.38
MC switching accuracy	2.50	2.15	2.42	1.79	0.21	.88
MC total score	27.42	3.99	25.67	4.31	2.12	.15

Table 45

Descriptive Statistics for Trails Sequencing Test Measure for MHI and No MHI Groups

	MHI		No MHI			
Variable	*M*	*SD*	*M*	*SD*	*F* (1, 46)	*p*
TRAILS number res. Time	30.94	11.42	33.55	9.35	0.74	.39
TRAILS number error	0.00	0.00	0.12	0.34	3.28	.07
TRAILS alphabet res. Time	29.00	10.25	30.44	10.38	0.23	.63
TRAILS alphabet acc.	0.12	0.45	0.00	0.00	1.86	.17
TRAILS switching res time	60.58	22.21	64.26	16.65	0.42	.52
TRAILS switching error	1.88	4.51	1.08	1.59	0.65	.42

Table 46

Descriptive Statistics for Pictorial Analogies Test (CTONI) Measure for MHI and No MHI Groups

	MHI		No MHI				
Variable	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*
CTONI pictorial analg. accuracy	15.65	3.26	15.00	3.19	(1, 43)	0.46	.50
CTONI pictorial analg. Resp. time	226.29	72.74	204.43	72.37	(1, 27)	0.63	.43

Table 47

Descriptive Statistics for Stroop Color-Word Interference Measure for MHI and No MHI Groups

	MHI		No MHI			
Variable	*M*	*SD*	*M*	*SD*	*F* (1, 46)	*p*
Stroop-Color naming resp.time	26.62	3.75	29.38	5.52	3.98	.05
Stroop-Color naming SC error	0.29	0.55	0.33	0.57	0.06	.79
Stroop-Color naming UC error	0.25	0.53	0.00	0.00	5.30	.02
Stroop-Word reading res. time	20.71	3.87	19.78	3.08	0.83	.36
Stroop-Word reading SC error	0.29	0.46	0.12	0.34	2.02	.16
Stroop-Word reading UC error	0.00	0.00	0.04	0.20	1.00	.32
Stroop-Inhibition resp. time	47.89	9.61	51.67	12.79	1.30	.25
Stroop-Inhibition SC error	1.42	1.35	1.38	1.25	0.12	.91
Stroop-Inhibition UC error	0.21	0.51	0.88	1.73	3.28	.07
Stroop-Inhibition/switching RP	54.01	8.42	57.90	12.19	1.56	.21
Stroop-Inhibition/switching SC err.	1.39	1.44	1.62	1.31	0.33	.56
Stroop-Inhibition/switching UC err.	1.00	1.28	1.62	3.69	0.59	.44

Table 48

Descriptive Statistics for Deliberate Physical Harm Ratings, HR activity (Onset), Executive Functioning Measures and MHI Status

Variable	*n*	*M*	*SD*
DP ratings	46	1.13	0.83
IDNM HR activity	46	76.99	9.07
DNM HR activity	46	77.02	8.84
IDNP HR activity	46	77.24	8.89
DNP HR activity	46	77.03	8.61
IDP HR activity	46	77.82	8.00
DP HR activity	46	77.10	7.80
MC- Number response time	46	4.55	1.20
MC- Number accuracy	46	3.57	0.77
MC- Days response time	46	2.43	0.75
MC-Days accuracy	46	2.98	0.57
Stroop-Color naming time	46	28.20	4.80
Stroop-Color naming UC	46	0.13	0.40
MHI status	46	0.48	0.50

Table 49

Inter-correlations of Deliberate Physical Harm Ratings with HR Activity (Onset), Executive Functioning Measures and MHI Status

						N = 46									
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DP ratings	_	-.25	-.30*	-.33*	-.29*	-.23	-.20	-.13	.31*	-.05	.02	.14	-.16	-.10	.25
IDNM HR		_	.95***	.93***	.91**	.92**	.87***	.31***	-.30*	.37**	-.24**	.06	.25*	-.32	-.20
DNM HR			_	.93***	.94***	.90***	.89***	.29*	-.29*	.35***	-.17	.04	.24	-.28*-.	19
IDNP HR				_	.93***	.91***	.88***	.25	-.23	.26	.20	.07	.24	-.31*	.20
DNP HR					_	.85***	.87***	.31**	-.30**	.34**	-.18	.04	.24*	-.23	-.20
IDP HR						_	.91***	.28	-.26	.34	-.26	.17	.25*	-.33	-.23**
DP HR							_	.28*	-.24*	.32*	-.23*	.20	.30*	-.28*	-.22*
MC-Number response time								_	-.84*	.24	-.20	.17	.30	.06	-.33*
MC-Number accuracy									_	.20	.22	.03	-.19	-.17	.31*
MC-Days response time										_	-.54***	.20	.15	-.04	-.44***
MC-Days accuracy											_	.01	-.11	.01	.34*

Table 49 Continued

Inter-correlations of Participants' Deliberate Physical Harms Ratings with HR Activity, Executive Functioning Measures and MHI Status

Trails-Number accuracy	_	.14	-.08	-.25
Stroop-Color naming response time		_	-.10	-.26
Stroop-Color naming UC			_	-.31*
MHI status				_

*$p<.05$

**$p < .01$

***$p < .001$

Table 50

Hierarchical Multiple Regression Analyses Predicting Deliberate Physical Harm Ratings from HR Activity (Onset), Executive Functioning Measures and MHI Status

Predictor	β	B	ΔR^2	$F\Delta$	*df*	*p*	sr^2
Step 1							
IDNM HR activity	0.61	0.05	0.20	1.63	6, 39	0.16	0.25
DNM HR activity	-0.75	-0.72					0.03
IDNP HR activity	-0.93	-0.08					0.06
DNP HR activity	0.23	0.02					0.00
IDP HR activity	0.19	0.02					0.00
DP HR activity	0.37	0.04					0.01
Step 2							
MC-Number time	0.47	0.33	0.17	1.28	7, 32	.34	0.05
MC-Number accuracy	0.66	0.71					0.09
MC-Days time	-0.11	-0.12					0.00
MC-Days accuracy	-0.13	-0.09					0.00
Trails Number error	0.04	0.13					0.00
Stroop-Color naming time	-0.15	-0.02					0.02
Stroop-Color naming UC	-0.11	-0.25					0.01
Step 3							
MHI status	0.18	0.30	0.01	0.90	1, 31	.28	0.01

Table 51

Descriptive Statistics for Unintentional Physical Harm Ratings, HR activity (Onset), Executive Functioning Measures and MHI Status

Variable	*n*	*M*	*SD*
IDP ratings	46	1.25	0.61
IDNM HR activity	46	76.99	9.07
DNM HR activity	46	77.02	8.84
IDNP HR activity	46	77.24	8.89
DNP HR activity	46	77.03	8.61
IDP HR activity	46	77.82	8.00
DP HR activity	46	77.10	7.80
MC- Number response time	46	4.55	1.20
MC- Number accuracy	46	3.57	0.77
MC- Days response time	46	2.43	0.75
MC-Days accuracy	46	2.98	0.57
Stroop-Color naming time	46	28.20	4.80
Stroop-Color naming UC	46	0.13	0.40
MHI status	46	0.48	0.50

Table 52

Inter-correlations of Unintentional Physical Harm Ratings with HR Activity (Onset), Executive Functioning Measures and MHI Status

N = 46

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
IDP ratings	—	-.09	.04	.09	.09	.17	.27	.03	.13	.00	.06	.32*	.17	-.16	.13
IDNM HR		—	.95***	.93***	.91**	.92**	.87***	.31***	-.30*	.37**	-.24**	.06	.25*	-.32	-.20
DNM HR			—	.93***	.94***	.90***	.89***	.29*	-.29*	.35***	-.17	.04	.24	-.28*	-.19
IDNP HR				—	.93***	.91***	.88***	.25	-.23	.26	.20	.07	.24	-.31*	.20
DNP HR					—	.85***	.87***	.31**	-.30**	.34**	-.18	.04	.24*	-.23	-.20
IDP HR						—	.91***	.28	-.26	.34	-.26	.17	.25*	-.33	-.23**
DP HR							—	.28*	-.24*	.32*	-.23*	.20	.30*	-.28*	-.22*
MC-Number response time								—	-.84*	.24	-.20	.17	.30	.06	-.33*
MC-Number accuracy									—	.20	.22	.03	-.19	-.17	.31*
MC-Days response time										—	-.54***	.20	.15	-.04	-.44***
MC-Days accuracy											—	.01	-.11	.01	.34*

Table 52 Continued

Inter-correlations of Participants' Unintentional Physical Harm Ratings with HR Activity (Onset), Executive Functioning Measures and MHI Status

Trails-Number accuracy	_	.14	-.08	-.25
Stroop-Color naming response time	_	-.10	-.26	
Stroop-Color naming UC			_	-.31*
MHI status				_

*p<.05

**p < .01

***p < .001

Table 53

Hierarchical Multiple Regression Analyses Predicting Unintentional Physical Harm Ratings from HR Activity (Onset), Executive Functioning Measures and MHI Status

Predictor	β	B	ΔR^2	$F\Delta$	*df*	*p*	sr^2
Step 1							
IDNM HR activity	0.27	0.01	0.28	2.56	6, 39	0.03	0.00
DNM HR activity	-1.24	-0.08					0.08
IDNP HR activity	-0.38	-0.02					0.01
DNP HR activity	0.30	0.02					0.00
IDP HR activity	0.13	0.01					0.00
DP HR activity	1.09	0.08					0.14
Step 2							
MC-Number time	0.29	0.14	0.17	1.28	7, 32	.34	0.01
MC-Number accuracy	0.38	0.30					0.03
MC-Days time	-0.02	-0.02					0.00
MC-Days accuracy	0.16	0.17					0.01
Trails Number error	0.07	0.17					0.00
Stroop-Color naming time	0.05	0.00					0.00
Stroop-Color naming UC	-0.06	-0.10					0.00
Step 3							
MHI status	-0.23	-0.29	0.31	1.65	1, 31	.20	0.03

Table 54

Descriptive Statistics for Deliberate Non-physical Harm Ratings, HR activity (Onset), Executive Functioning Measures and MHI Status

Variable	*n*	*M*	*SD*
DNP ratings	46	1.54	0.67
IDNM HR activity	46	76.99	9.07
DNM HR activity	46	77.02	8.84
IDNP HR activity	46	77.24	8.89
DNP HR activity	46	77.03	8.61
IDP HR activity	46	77.82	8.00
DP HR activity	46	77.10	7.80
MC- Number response time	46	4.55	1.20
MC- Number accuracy	46	3.57	0.77
MC- Days response time	46	2.43	0.75
MC-Days accuracy	46	2.98	0.57
Stroop-Color naming time	46	28.20	4.80
Stroop-Color naming UC	46	0.13	0.40
MHI status	46	0.48	0.50

Table 55

Inter-correlations of Deliberate Non-physical Harm Ratings with HR Activity (Onset), Executive Functioning Measures and MHI Status

					$N = 46$										
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DNP ratings	_	-.09	-.14	-.15	-.12	-.11	-.28	- .06	.19	-.13	.03	.21	-.03	-.25	.17
IDNM HR		_	.95***	.93***	.91**	.92**	.87***	.31***	-.30*	.37**	-.24**	.06	.25*	-.32	-.20
DNM HR			_	.93***	.94***	.90***	.89***	.29*	-.29*	.35***	-.17	.04	.24	-.28*-.	19
IDNP HR				_	.93***	.91***	.88***	.25	-.23	.26	.20	.07	.24	-.31*	.20
DNP HR					_	.85***	.87***	.31**	-.30**	.34**	-.18	.04	.24*	-.23	-.20
IDP HR						_	.91***	.28	-.26	.34	-.26	.17	.25*	-.33	-.23**
DP HR							_	.28*	-.24*	.32*	-.23*	.20	.30*	-.28*	-.22*
MC-Number response time								_	-.84*	.24	-.20	.17	.30	.06	-.33*
MC-Number accuracy									_	.20	.22	.03	-.19	-.17	.31*
MC-Days response time										_	-.54***	.20	.15	-.04	-.44***
MC-Days accuracy											_	.01	-.11	.01	.34*

Table 55 Continued

Inter-correlations of Participants' Deliberate Non-physical Harm Ratings with HR Activity, Executive Functioning Measures and MHI Status

Trails-Number accuracy	_	.14	-.08	-.25
Stroop-Color naming response time	_	-.10	-.26	
Stroop-Color naming UC			_	-.31*
MHI status				_

*p<.05

**p < .01

***p < .001

Table 56

Hierarchical Multiple Regression Analyses Predicting Deliberate Non-physical Harm Ratings from HR Activity (Onset), Executive Functioning Measures and MHI Status

Predictor	β	B	ΔR^2	$F\Delta$	*df*	*p*	sr^2
Step 1							
IDNM HR activity	0.38	0.03	0.09	0.65	6, 39	0.68	0.05
DNM HR activity	-0.44	-0.03					0.03
IDNP HR activity	-0.07	-0.00					0.01
DNP HR activity	0.30	0.02					0.00
IDP HR activity	-0.72	-0.07					0.01
DP HR activity	0.47	0.04					0.07
Step 2							
MC-Number time	0.11	0.07	0.26	1.91	7, 32	.34	0.00
MC-Number accuracy	0.33	0.33					0.01
MC-Days time	-0.23	-0.23					0.04
MC-Days accuracy	-0.42	-0.56					0.01
Trails Number error	0.22	0.68					0.02
Stroop-Color naming time	-0.04	-0.00					0.00
Stroop-Color naming UC	-0.32	-0.61					0.06
Step 3							
MHI status	0.32	0.48	0.04	2.48	1, 31	.12	0.00

Table 57

Descriptive Statistics for Post Concussion Syndrome Checklist Measure for MHI and No-MHI Groups

	MHI		No MHI	
Variable	*M*	*SD*	*M*	*SD*
Total score	65.21	11.62	62.70	19.92
Frequency score	20.13	4.11	19.65	7.15
Intensity score	20.75	4.11	19.83	6.35
Duration score	24.33	4.34	23.22	6.82

Table 58

Mean and Sum of Ranks for the Frequency of Post Concussion Symptoms for MHI and No-MHI Groups

	MHI		No MHI			
Variable	*M*	*Sum*	*M*	*Sum*	*z*	*p*
Headache	24.71	593.00	23.26	535.00	-.39	.69
Dizziness	24.85	596.50	23.11	531.50	-.48	.62
Irritability	25.58	614.11	22.35	514.00	-.86	.38
Memory problems	25.21	605.00	22.74	523.00	-.70	.48
Concentration diff.	23.92	574.00	24.09	554.00	-.04	.96
Fatigue	25.62	615.00	22.30	513.00	-.86	.38
Visual disturbances	22.69	544.50	25.37	583.50	-1.02	.30
Aggravated by noise	24.56	589.50	23.41	538.50	-.32	.74
Judgment	25.50	612.00	22.43	516.00	-1.00	.31
Anxiety	26.46	635.00	21.43	493.00	-1.32	.18

Table 59

Mean and Sum of Ranks for the Intensity of Post Concussion Symptoms for MHI and No-MHI Groups

	MHI		No MHI			
Variable	*M*	*Sum*	*M*	*Sum*	*z*	*p*
Headache	24.06	577.50	23.93	550.50	-.03	.97
Dizziness	25.67	616.00	22.26	512.00	-.96	.33
Irritability	25.90	621.50	22.02	506.50	-1.01	.30
Memory problems	26.10	626.50	21.80	501.50	-1.24	.21
Concentration diff.	23.88	573.00	24.13	555.00	-.06	.94
Fatigue	24.98	599.00	22.98	528.50	-.52	.59
Visual disturbances	23.25	558.00	24.78	570.00	-.61	.53
Aggravated by noise	25.48	611.50	22.46	516.50	-.87	.38
Judgment	24.77	594.50	23.20	533.50	-.60	.54
Anxiety	24.75	594.00	23.22	534.00	-.40	.68

Table 60

Mean and Sum of Ranks for the Duration of Post Concussion Symptoms for MHI and No-MHI Groups

	MHI		No MHI			
Variable	*M*	*Sum*	*M*	*Sum*	*z*	*p*
Headache	23.35	560.50	24.67	567.50	-.37	.71
Dizziness	25.50	612.00	22.43	516.00	-.86	.38
Irritability	25.00	600.00	22.96	528.00	-.53	.59
Memory problems	24.69	592.50	23.28	535.00	- .40	.68
Concentration diff.	25.12	603.00	22.83	525.00	-.60	.54
Fatigue	24.79	595.00	23.17	533.00	-.46	.64
Visual disturbances	23.46	563.00	24.57	565.00	-.46	.64
Aggravated by noise	25.48	611.50	22.46	516.50	-.87	.38
Judgment	25.27	606.50	22.67	521.50	-.94	.34
Anxiety	24.58	590.00	23.39	538.00	-.40	.68

Appendix C: Checking assumptions for multiple regression predicting unintentional non-Physical harm ratings

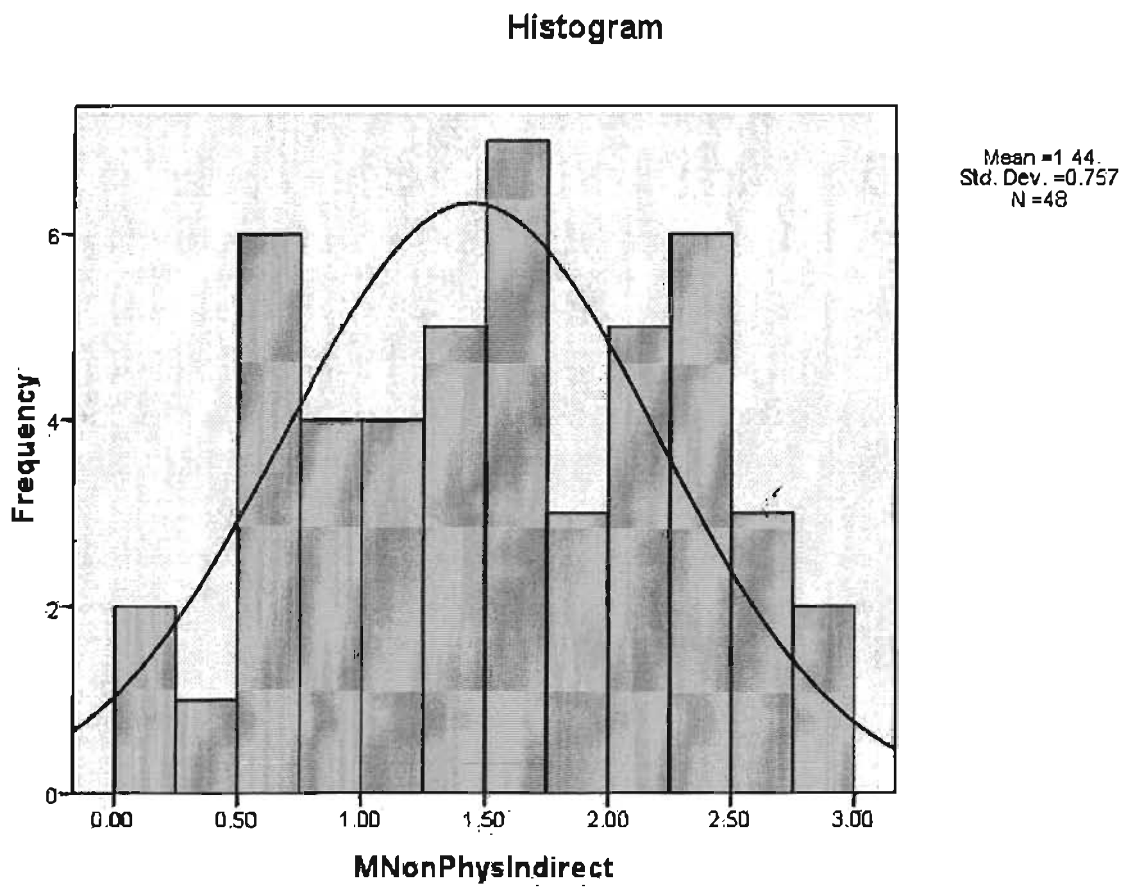
Normality Analysis for Unintentional Non-Physical Harm Violations

Statistics

MNonPhysIndirect

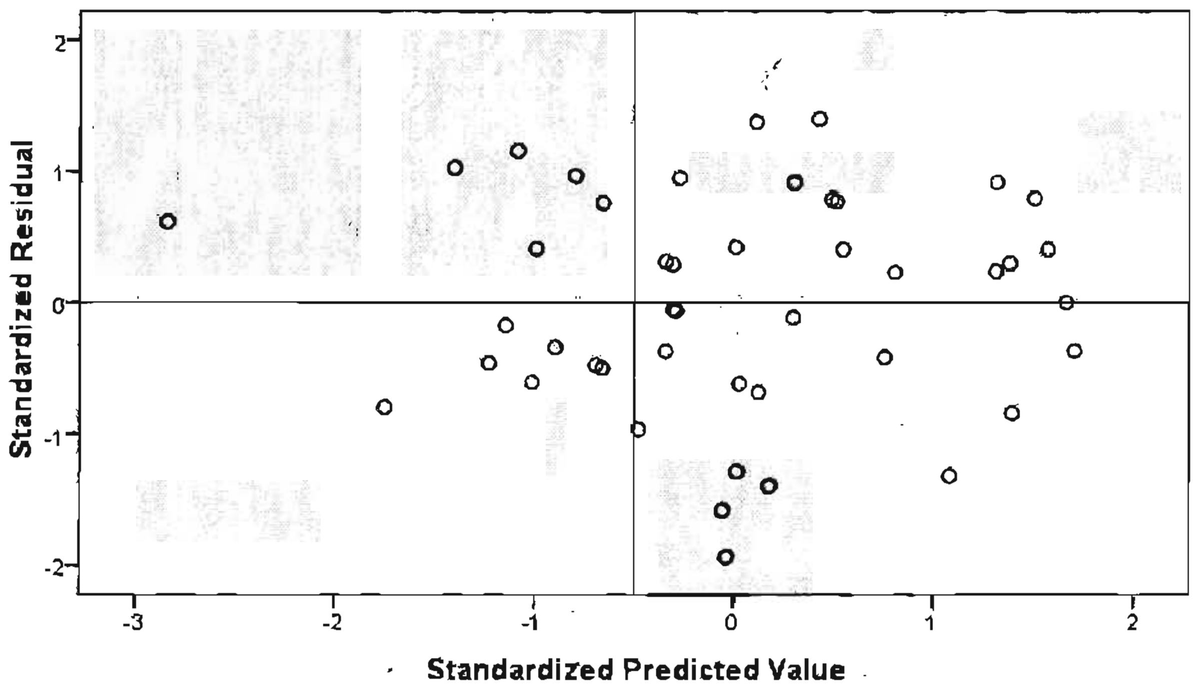
N	Valid	48
	Missing	1
	Mean	1.4410
	Median	1.5000
	Mode	.50[a]
	Std. Deviation	.75681
	Skewness	-.068
	Std. Error of Skewness	.343
	Kurtosis	-.964
	Std. Error of Kurtosis	.674
	Minimum	.00
	Maximum	2.75

a. Multiple modes exist. The smallest value is shown


Histogram
Mean =1.44
Std. Dev. =0.757
N =48
Frequency
0
2
4
6
0.00
0.50
1.00
1.50
2.00
2.50
3.00
MNonPhysIndirect

Graph: Checking Homoscedasticity

Dependent Variable: MNonPhysIndirect



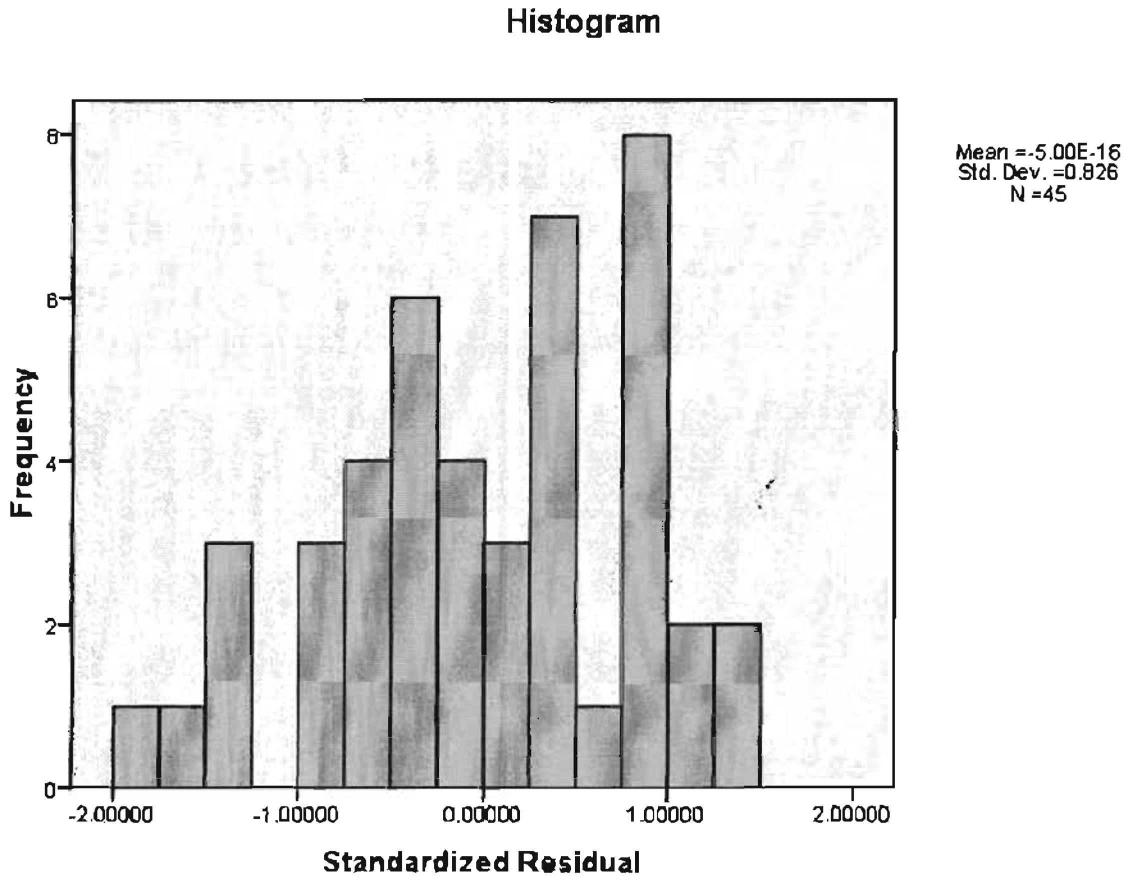
Normality Analysis of Residuals

Statistics

Standardized Residual

N	Valid	45
	Missing	4
	Mean	.0000000
	Median	.0011407
	Mode	-1.93961[a]
	Std. Deviation	.82572282
	Variance	.682
	Skewness	-.343
	Std. Error of Skewness	.354
	Kurtosis	-.542
	Std. Error of Kurtosis	.695
	Minimum	-1.93961
	Maximum	1.40038

a. Multiple modes exist. The smallest value is shown


Histogram
Mean =-5.00E-16
Std. Dev. =0.826
N =45
Frequency
0
2
4
6
8
-2.00000
-1.00000
0.00000
1.00000
2.00000
Standardized Residual

Graph: Checking Misspecification of the model